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EUTROPHICATION OF SURFACE WATERS - LAKE TAHOE'S INDIAN CREEK RESERVOIR

P. H. McGauhey, et al

Lake Tahoe Area Council

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16. Abstract From April 1969 to October 1974 field and laboratory analyses and observations were made at approximately weekly intervals to evaluate the relationship between the quality of water impounded at Indian Creek Reservoir (ICR) and the reclaimed water exported by the South Tahoe Public Utility District. The reclaimed water comprised from 70 to 80 per cent of the annual impoundment. On the average the reclaimed water contained 0.1 to 0.2 mg/l of phosphorus and 15-24 mg/l of ammonia, the latter making it toxic to fish implanted in ICR. However, as the reservoir matured, nitrification-denitrification removed most of the nitrogen from the system and by March 1970 the reservoir had become an excellent trout fishery. Excess N in comparison with P evidently precluded blooms of blue green algae but low phosphorus did not prevent the impoundment from becoming typical of a highly productive environment, with vascular plants invading to considerable depths because of the high degree of clarity of the reclaimed water. By 1974 the biosystem was at an approximately steady state. This state may not remain because of the appearance of epiphytic blue green algae which caused taste and odor problems in the water and in the fish. It is concluded that the reservoir responds to more complex factors than are measurable by analysis of reclaimed water. The results show why a system of wastewater reclamation must be designed on the basis of the natural as well as the man-controlled components of the system, and points the way to the necessary parameters and institutional concepts if water is to be reclaimed for a specific purpose.

*Eutrophication, *Nitrification, *Denitrification, *Reclaimed Wastes, *Aquatic Productivity, *Density, *Bioassay, *Limnology, *Cycling Nutrients, *Benthos, Aquatic Microorganisms, Algae, Vascular Plants, Fish Population, Tertiary Treatment, Nutrients, Nutrient budget, Biomass

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FEBRUARY 1975

EUTROPHICATION OF SURFACE WATERS ---
LAKE TAHOE'S INDIAN CREEK RESERVOIR

by

Lake Tahoe Area Council

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Project Officer

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ABSTRACT

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This report was submitted in fulfillment of Grant No. 801003 by the Lake Tahoe Area Council under the sponsorship of the Environmental Protection Agency. Work was completed as of October 31, 1974.

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During the report period herein presented (1971-1974), project management of an engineering and scientific nature continued under the guidance of P. H. McGauhey, Project Director, who also donated a portion of his time to the project as a public service. Field observations and sampling, laboratory and microscopic analyses, bioassays, and data tabulation and plotting were performed by Mr. John D. Archambault and Mrs. Nancy M. Deliantoni, the latter assuming full responsibility during the final three months of the project. The biological and limnological aspects of the project, special field studies, final data and analysis, and preparation of the final report were guided by Dr. Donald B. Porcella, Utah State University (formerly Project Limnologist on the project), serving as a consultant on an "as needed" basis. Budgetary control and accounting were maintained by Mrs. Lorrene Kashuba and Mrs. Katharine Belyea of the LTAC staff.

A special underwater photographic survey of the benthic conditions of the reservoir was made by Dr. Thomas Walsh, Environmental Quality Analysts, Inc., with the assistance of Dr. Porcella, Dr. Gordon L. Dugan, University of Hawaii (formerly project Engineer-Biologist), and Mr. Peter A. Cowan, Utah State University (formerly project research biologist), and the resident staff of the project. An examination of benthic invertebrates was made during the report period by Dr. Arthur W. Noble (Environmental Quality Analysts, Inc.), extending data he had previously observed while employed by the Alameda laboratory of the EPA. Zooplankton identification counts were made by Dr. J. Anne Holman, Utah State University. Aerial surveys via infrared and color photography to reveal the extent of underwater weed growth were made by Natural Resources Consultants, Reno, Nevada.

Data on the quality and quantity of reclaimed water exported to ICR and on discharges from the reservoir were furnished by the South Tahoe Public Utility District through Mr. Russell L. Culp, General Manager. John Gonzales, Engineer at STPUD, was extremely helpful. The California Department of Fish and Game contributed facilities as well as data on fish population, fish catches, and the suitability of the reservoir environment for fishes. Russ Wickwire, Fish and Game Biologist, contributed his special knowledge about ICR as well as time. The University of California at Davis and Berkeley contributed expert advice and loaned equipment when needed. Professor Erman A. Pearson, University of California (one of the original LTAC Board of Consultants which conceived and guided the study), loaned personally owned sampling equipment to the project.

Graphic work on the final report was done by Mr. Peter Bray; tables were prepared by Mrs. Flora Orsi; and manuscript typing was performed by Barbara South, Betty Hansen, and Gretta Curless, D. Anderson.

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SECTION I

CONCLUSIONS

HYDROLOGIC AND PHYSICAL MEASUREMENT

1. The flow of STPUD effluent into ICR is seasonally variable but shows an increasing trend paralleling that of population growth in the Lake Tahoe Basin.

2. As might be expected from the tendency of STPUD effluent to increase with time, estimates of water inputs and outputs show that reclaimed water from the STPUD is an increasing percentage of the total impounded at ICR at any time and, consequently, of the discharges to irrigation; the water budget estimates are deemed reasonably accurate because percolation rates (estimated by difference) are comparable to values measured in other similar impoundments of water.

3. Maximum Secchi disc readings were 8.8 m (28.5 feet), indicating a high clarity for water which normally would be treated as a waste. Generally the clarity is greatest in spring and fall; intermediate clarity is found during mid-summer and minimum clarity during February through March during peak phytoplankton populations.

4. After a time lag, temperature in the reservoir follows air temperatures. Temperatures range from freezing (0°C) to about 22°C during July and August. Generally ice cover is only partial and occurs during December and January.

OBSERVATIONS OF MACROCHEMICALS

5. Difference between STPUD effluent and impounded water for COD were ascribed primarily to an increase resulting from algal growth.

6. SS and VSS were generally less in ICR than in STPUD effluent; this was probably caused by a settling of SS materials in the reservoir. When levels in ICR were greater, the difference was ascribed primarily to wind action suspending bottom sediments; during the spring high VSS values were ascribed to phytoplankton.

7. Chloride, the conservative tracer of STPUD effluent, has consistently increased in the reservoir as a result of the concentrating effects of evaporation.

8. Conductivity in ICR also has increased with time because of evaporation. Conductivity is significantly less in ICR than in STPUD effluent. This is ascribed to removal of ions such as Ca^{++} and HCO_3^-. The conductivity levels in ICR indicate a high quality for irrigation purposes.

9. Calcium and alkalinity both decreased significantly in ICR from values measured in the STPUD effluent. Precipitation of $CaCO_3$ is responsible for some of this decrease.

10. pH in ICR water is extremely constant at about 8.0, being similar to that of STPUD effluent; higher values, however, occur during the late spring, reflecting the onset of increased photosynthetic activity.

11. About 10 percent of the influent alkalinity is removed as a result of inorganic carbon utilization in photosynthesis.

NUTRIENT FATE AND UTILIZATION AND EFFECTS ON OXYGEN

12. Bicarbonate carbon is significantly reduced primarily by photosynthesis.

13. Little organic phosphorus was measured in ICR during the last year of study.

14. Orthophosphate concentration is higher during winter than summer; minimum values were less than 1 μg P/ℓ except when phosphorus loadings were intentionally increased by the STPUD for experimental purposes in 1972-1973.

15. Phosphorus concentrations in the reservoir showed an immediate response to higher input phosphorus. The concentration of phosphorus increased markedly in the reservoir, reversing an apparent earlier trend of gradual diminution of phosphorus in the aqueous phase during periods of high plant growth.

16. High quantities of inorganic nitrogen as ammonium (18-24 mg N/ℓ) have entered ICR, resulting in high inorganic nitrogen concentrations in the reservoir--10 mg N/ℓ in 1974 of which 50 percent is NH_4-N and 50 percent NO_3-N.

17. Ammonium acts as an oxygen sink (nitrification) and a nitrogen source in plant growth. The high nitrogen availability insures that nitrogen is not limiting to plant growth.

18. Inorganic nitrogen concentration in ICR responds rapidly to high inputs of ammonium nitrogen, increasing in scale with the input concentration increase.

19. Iron is relatively low in concentration, which may indicate that it could be limiting to plant growth relative to other nutrients measured.

20. Estimates of the nitrogen and phosphorus inventories support previous estimates that 40-50 percent of the nitrogen and about 60 percent of the phosphorus is removed from the aquatic system; previous studies showed nitrogen was removed principally by nitrification-denitrification and phosphorus transferred principally into the sediments.

21. Dissolved oxygen largely coincides with saturation calculations except during periods of high photosynthetic activity: phytoplankton during the winter and aquatic vascular plants during the early summer and in the fall.

22. High dissolved oxygen concentrations at all depths indicate a change from previous results which showed a large oxygen deficit in the bottom layers of the reservoir. Because of the high oxygen concentration throughout all reservoir depths, it is possible that denitrification is not as significant as previously. Nitrification is apparently not such a significant sink for oxygen that an oxygen deficit occurs.

23. During the fall season marked increases in dissolved oxygen were seen in bottom layers, apparently due to benthic oxygen production.

24. Significant quantities of organic carbon, nitrogen and phosphorus are in the upper layers of the sediments. Lower layers of sediments have essentially the same quantity of these elements as soil in the ICR basin.

25. Ratios of organic carbon, nitrogen and phosphorus indicate appreciable removal by settling of plant material; however, phosphorus ratios are indicative of precipitation--probably as calcium and iron phosphates.

BIOLOGICAL OBSERVATIONS

26. Plankton microorganisms show a diversity typical of relatively high productivity ecosystems.

27. Aufwuchs growth measured on glass slides had a maximum specific growth rate of 0.4 days^{-1}. This approximates what would be estimated from laboratory algal bioassays for the nutrient levels in the reservoir.

28. Algal bioassays integrate the independent variations in concentrations of specific nutrients. Results implicated phosphorus as the limiting nutrient in ICR relative to nitrogen. Growth rates in bioassays appeared inversely related to the biological growth cycle of the reservoir.

29. STPUD effluent is toxic to algal cultures used in bioassays.

30. Because high growth rates were obtained in ICR samples yet phytoplankton concentrations were relatively low and transparency high, it was reasoned that predation prevented phytoplankton blooms. The types of phytoplankton present would have a great influence on the possible role of predation in controlling algal blooms.

31. Benthic vegetation was primarily Cladophora in deeper waters and Myriophyllum in shallower waters. The expansion of flora over greater areas occurred as drawdown of the reservoir during the irrigation season increased light transmission in deeper waters.

32. Extensive aquatic vascular plant production is interfering with recreational uses in the reservoir and represents a control cost to STPUD

33. Epiphytic blue-green algae (Oscillatoria) have been observed growing on the aquatic weeds and are responsible for a developing taste and odor problem at ICR observed in September 1974.

34. The diversity of zooplankton populations is typical of productive impoundments. The trend in zooplankton populations is for greater stability than earlier samplings showed.

35. Benthic fauna measurements support previous results showing that the further from Station 1 (adjacent to the STPUD effluent outfall in ICR), the greater the diversity.

36. Snails are quite evident in ICR and form a large part of trout diet; numbers approach 500/square meter in dried aquatic weed beds along exposed shoreline.

37. Trout survive very well in ICR except for an episode of toxicity (apparently caused by free ammonia) observed in March 1972.

38. Rapid growth rates and large fish are typical of the trout population. Fishing success is not too high, and this has been ascribed to the high amount of feed and interference with fishing caused by the dense aquatic weed growths.

39. Taste and odor problems from the epiphytic Oscillatoria growth have affected the flavor of the trout flesh.

SOME IMPLICATIONS OF FINDINGS

40. The STPUD wastewater reclamation plant is a highly efficient system for removing phosphorus, and the impoundment at ICR is an effective system for removing nitrogen from domestic sewage.

41. Although the STPUD plant successfully performed its design function in demonstrating the ability of known processes to produce a highly clarified, low phosphorus effluent meeting drinking water standards, the suitability of its effluent for fish life and associated recreational values has resulted from further changes in water quality by limnological phenomena in the ICR system for which no design criteria are available.

42. The results of the ICR studies indicate clearly that purifying wastewater to the highest degree possible by current technology does not insure its optimum suitability for all further purposes; but rather that design parameters must eventually include the entire system. The study suggests what some of these relationships may be and points the direction for necessary further studies.

43. The findings of the study indicate that the relative nitrogen surplus resulting from phosphorus removal at the STPUD plant and the transformations occurring in ICR was sufficient to prevent blooms of nitrogen-fixing blue green algae. Further studies are needed before anyone can say whether a greater or lesser degree of phosphorus removal, and consequent changes in cost-effectiveness, would achieve this same goal.

44. The high degree of clarity achieved by the STPUD plant although enhancing the initial aesthetic quality of the reclaimed water results in light penetration and, consequently, aquatic weed growth in greater depths of water.

45. Gentle slopes, a relatively shallow reservoir, great clarity, and the fill and draw operating schedule of ICR all contribute to a large percentage of bottom area supportive of vascular plants, a condition increasingly destructive of the recreational value of ICR.

46. Apparently, phosphorus is not limiting to weed growth in ICR. Neither has weed cutting and removal proved effective as a control method for weeds.

47. From the foregoing factors, together with data presented in detail in the report, it is evident that a wastewater treatment system in the STPUD/ICR situation, if designed for a recreational impoundment and winter storage for summer drawdown in irrigation, would involve a deep reservoir with a minimum of shallow water under all conditions of operation, fed with an effluent in which phosphorus concentrations were no less than necessary, and clarity no greater than that which nature will dictate in the reservoir.

48. The ICR studies have pioneered along the road to wastewater treatment processes appropriately divided between man-controlled and natural reactors to achieve the objectives of an overall system; but

much is yet to be done to define the system parameters and to institutionalize the concepts required for accurate engineering design to meet society's environmental goals.

SECTION II

RECOMMENDATIONS

The results of studies of Indian Creek Reservoir made by the Lake Tahoe Area Council under a series of grants from the Environmental Protection Agency reveal, perhaps for the first time, the limnological changes which might be expected in an impoundment of water reclaimed from domestic wastewater flows. In late 1968 when impoundment of tertiary effluent from the South Tahoe Public Utility District was begun at Indian Creek Reservoir, the quality characteristics of the reservoir water closely resembled that of the influent reclaimed water and was incapable of supporting fish life. Thereafter it changed rapidly and progressively to a system more clearly complex and highly productive of aquatic life, including trout which were planted in it in great numbers. Details of these changing characteristics and of the underlying phenomena were reported in 1971 [5]. The results suggested that some of the processes applied in the tertiary treatment of sewage were of questionable utility in conditioning wastewater for use in recreational ponds. To evaluate this suggestion and to monitor further changes in the characteristics of impounded reclaimed water, studies were continued through the years 1972, 1973, and 1974. The results, herein reported, show further changes in the quality of reservoir water which indicate that the impoundment has not yet reached maturity and that the system is even more complex than previously revealed. In fact, there is evidence that management techniques both in terms of wastewater treatment and reservoir management may yet require further refinement if water quality is not to decline.

Therefore, it is recommended that federal and state agencies concerned with water quality control should continue a program to monitor seasonal and yearly changes in the quality of ICR for the purpose of evaluating both the resolving power of wastewater treatment processes and the management of recovered water as a resource. It is further recommended that studies beyond the scope of the Indian Creek Reservoir study herein reported, but suggested by its findings, be conducted for the purpose of determining: 1) the feasibility of utilizing intermediate size ponds to reduce the nitrogen content of a phosphate-stripped water, and 2) the optimum nutrient levels and morphological relationships for impoundments to be used for recreational or other specific benefits, with the intent of establishing more rational parameters of treatment plant design.

SECTION III

INTRODUCTION

ORIGIN OF INDIAN CREEK RESERVOIR

Indian Creek Reservoir is the terminus of a system designed to export from the Lake Tahoe Basin the final effluent from the domestic waste water treatment facilities of the South Tahoe Public Utility District (STPUD). The concept that sewage should be removed from the Tahoe Basin developed during the early nineteen sixties. At that time it was becoming widely apparent throughout the U.S.A. that the growing population pressure on the nation's water resources was leading to overfertilization of surface waters with consequent algal blooms that interfered with normal beneficial use of such resources. In many instances losses were identifiable in economic terms as well as in depreciated aesthetic and recreational values.

In the specific case of Lake Tahoe, discharge of waste water effluents directly into the lake had never been considered an acceptable alternative. However, prior to about the year 1960 disposal on land within the basin was generally considered adequate to overcome the public health and aesthetic objections to discharge into surface waters of the region. Nevertheless, it was recognized by water quality control authorities and others that the clarity and beauty of Lake Tahoe was a consequence of an extremely low productivity resulting from its oligotrophic (nutrient poor) characteristics. Moreover, it was evident that the Lake Tahoe Basin is essentially a closed system subject to human imports of nutrients but to only limited export of nutrients, principally via the Truckee River and some selective logging. Thus the lake is the ultimate nutrient sink in the basin. In such a situation in 1960, sewage disposal was considered the most critical unsolved problem.

Under a grant from the Max C. Fleischmann Foundation of Reno, Nevada, the Lake Tahoe Area Council conducted a comprehensive study on protection of the water resources in the Lake Tahoe Basin through management of wastes. The resulting report [1] recommended export as one of the three feasible alternatives. At about the same time (1961) the STPUD retained consulting engineers to develop a long-range permanent solution to its disposal problems.

The idea of export as a practical solution to the waste management problem of the Lake Tahoe Basin, however, developed slowly. No community was willing to be the terminus of any waste export scheme. The concept that water is forever "sewage" once it has been used to transport wastes proved to be too deeply ingrained in the minds of citizens to be overcome by simple persuasion. "If it is not good enough for you, it is not good enough for me" was the ultimate attitude. This rationale precluded both export by way of the Truckee River and by pipeline as well, although the latter offered more possible alternatives.

Matters were finally brought to a head as a result of a growing national concern over eutrophication. This initiated a review of water quality criteria that has increasingly led in the direction of nutrient removal as an obligatory objective of waste water treatment. A series of demonstration grants to the STPUD were made under the Advanced Waste Water Treatment program of the series of federal agencies which culminated in the Environmental Protection Agency. These grants led to the development on a plant scale of processes for nutrient removal and for upgrading waste water in quality to drinking water standards. Thereafter to make export feasible it was only necessary for people to understand that what constitutes acceptable high quality water almost anywhere is not adequate to protect Lake Tahoe from eutrophication because of the lake's sensitivity to nitrogen at levels far below those acceptable for drinking water.

The Indian Creek Reservoir site was selected as a logical place to impound reclaimed water because it offered an agricultural use of water without release to surface streams.

CHARACTERISTICS OF INDIAN CREEK RESERVOIR

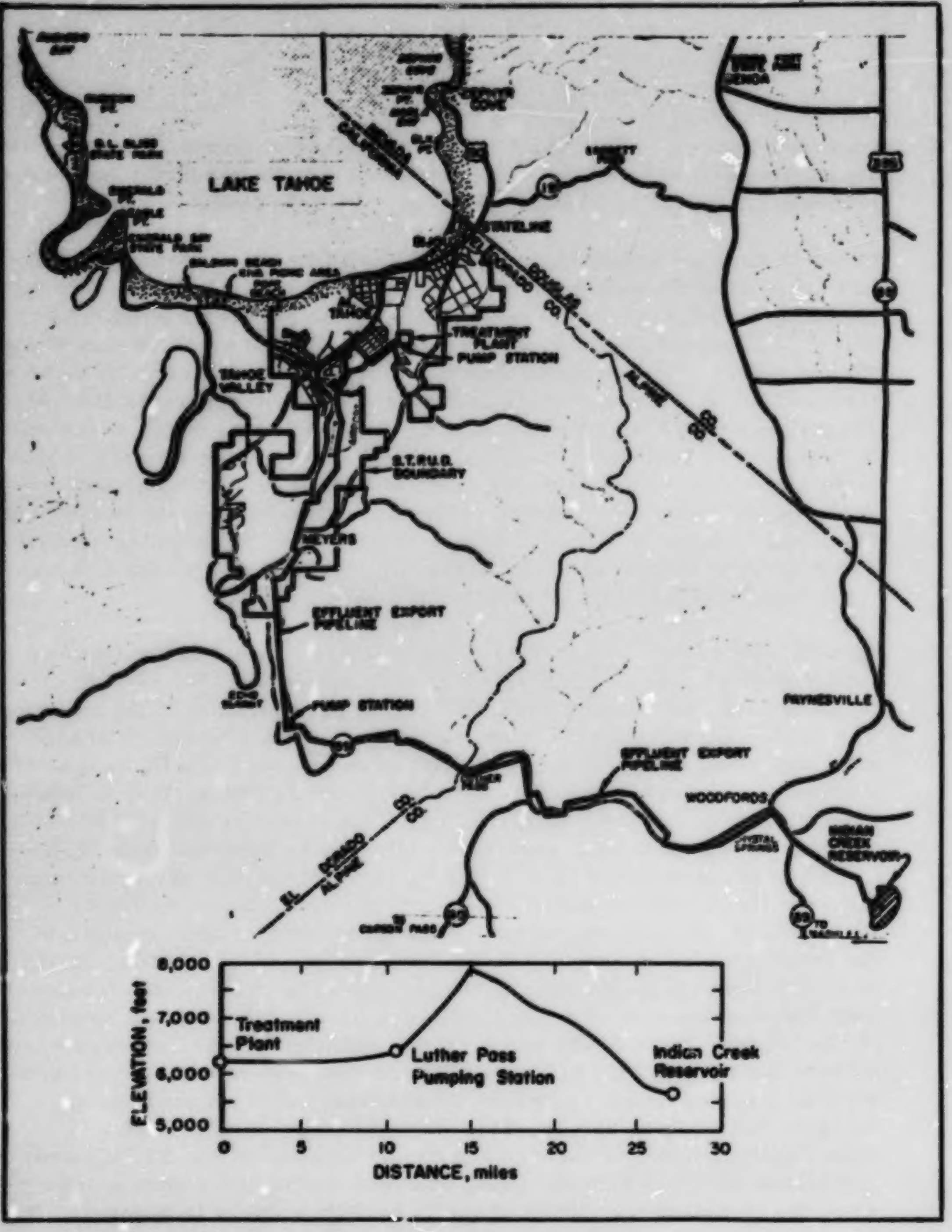
Indian Creek Reservoir is located in Alpine County, California on the eastern side of the Sierra Nevadas on a tributary of Indian Creek in

Diamond Valley. Figure 1 shows its general relationship to Lake Tahoe, Luther Pass, and other geographical features of the area, as well as the profile of the 43.5 km (27 miles) reclaimed water export line from South Lake Tahoe.

The reservoir was formed in 1968 by the construction of a rockfill dam, 20.7 m (68 feet) in height, across the tributary to Indian Creek, together with a smaller saddle dam of the same type to prevent overflow of the reservoir into a shallow and little used impoundment known as Stevens Lake. In preparing the reservoir site the original vegetation, comprising mostly scrub brush and pinon pine, was removed and the existing shallow soil stripped down to a stratum of quite impervious hardpan and rock which characterizes the area. In this manner it was intended to minimize the organic matter initially present on the bottom of the reservoir which might subsequently become a nutrient for organic growth in the overlying water. The reservoir has a maximum depth of 17 m (56 feet) and maximum mean depth of 6 m (19.5 feet).

The spillway crest of the main dam was established at an elevation of 1707 m (5600 feet) above mean sea level. Thus it is about 190.5 m (625 feet) below the water surface elevation of Lake Tahoe and some 640 m (2100 feet) below the summit of Luther Pass. At maximum water surface elevevation (5600 feet) the surface area of the reservoir is approximately 64.8 hectares (ha) (160 acres), or about 9 percent of the 688 ha (1700 acres) of drainage area above the dam. The maximum volume of impounded water is about 3,860,000 cubic meters (3130 acre feet).

Although the reclaimed water from the STPUD is essentially of drinking water quality, its disposal to the Carson River system is not permitted under standards established to preserve the exceptionally low dissolved solids content of the west Carson River. Therefore the reservoir is operated without overflow by releasing to irrigated agriculture during the growing season the water impounded during the previous winter. This results in a maximum variation in water surface elevation between 1707 and 1701 meters (5600 and 5582 feet) and a volume variation between 3,860,000 and 1,230,000 cubic meters (3130 and 1000 acre feet). Such an extreme variation, however, is not expected to occur until after the year 2000, at which time the anticipated export from South Lake Tahoe will approach the 1701 meters (14,000 acre feet) of water that agriculture in the immediate area can probably accept at its full potential. Thus it is evident that the operational schedule of Indian Creek Reservoir will have some seasonal effects on the quality of the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S.T.P.U.D. BOUNDARY
MEYERS
EFFLUENT EXPORT PIPELINE
ECHO SUMMIT
PUMP STATION
LUTHER PASS
EFFLUENT EXPORT PIPELINE
PAYNESVILLE
WOODFORDS
INDIAN CREEK RESERVOIR
TO CARSON PASS
50
19
89
88
395
ELEVATION, feet
8,000
7,000
6,000
5,000
Treatment Plant
Luther Pass Pumping Station
Indian Creek Reservoir
0
5
10
15
20
25
30
DISTANCE, miles

FIGURE I. GEOGRAPHICAL RELATIONSHIPS, INDIAN CREEK RESERVOIR AND EXPORT LINE FROM LAKE TAHOE BASIN (2,3)

impounded water. Since the reservoir reached maximum capacity, the annual fluctuation in volume of water stored in the reservoir has ranged between 1.2 to 1.6 million m^3 (1000 to 1300 acre feet).

Other factors governing the quality of stored water, beyond the degree of treatment of the water exported by the STPUD, include the climatological and hydrological characteristics of the reservoir area. As shown in Figure 2 (Section IV) the long axis of the reservoir lies along the meridian. Thus it parallels roughly the adjacent Sierra Nevadas to the west. The mountain range in turn protects the reservoir from the prevailing winds but guides local winds along the axis of the reservoir on a generally south to north path. Cover on the drainage area varies from pinon pine on the east to a stand of timber intermingled with scrub brush on the west. This cover varies in density from quite heavy brush to isolated stands of timber. Slopes are steepest on the west; on the order of 10 to 20 percent at lakeside. To the east the slopes are more moderate, averaging about one-half the values cited.

The climate of the Indian Creek area is typical of that of the eastern or "rain shadow" side of the Sierras at altitudes in the 1520 to 1830 m (5000 to 6000 feet) range. Average annual precipitation at the reservoir is reported [2] to be about 51 cm (20 inches), with 70 percent of this total occurring during the winter, November through April, season of the year. Although snowfall is substantial during the winter, rainfall accounts for much of the precipitation. Average monthly records from the U.S. Weather Bureau gage at Woodfords, California, some 4.8 km (3 miles) northwest of Indian Creek Reservoir, show a variation from 0.86 cm (0.34 inches) in the months of July and August, to 10.9 cm (4.28 inches) in January, when prevailing storms occur. In spite of the small amount of summer rainfall it is likely to be intense. Rapid rise of heated air up the face of the mountains occasions thunderstorms and, because the soil in the Indian Creek area is shallow and on appreciable slopes, some of the summer precipitation can be expected to run off into the reservoir. At times of more seasonal rainfall or of snowmelt on frozen ground, however, considerably more input of meteorological water is to be expected. In contrast with natural runoff, inputs to the reservoir through the export pipeline of the STPUD are continuous the year around, being greatest during the summer season when the transient population of the Lake Tahoe Basin is greatest. Thus the effect of surface runoff on the nature of water reaching the reservoir is less in summer than would normally result from climatological variation in the Indian Creek area. An estimate of the nature of this variation reported in 1970 [4] was as follows:

1. Maximum monthly runoff of surface water to reservoir, approximately 49 times the minimum.

2. Maximum input of reclaimed water: approximately 6.4 times the minimum.

3. Minimum ratio of reclaimed water to surface runoff: 1/2.66 (January).

4. Maximum ratio of reclaimed water to surface runoff: 118/1 (July, August, September).

5. Anticipated composition of impounded water of annual influent basis:

Meteorological water	30 percent
Reclaimed water	70 percent

As of April 1974 the influent composition has changed due to the increase in reclaimed water inflow:

Meteorological water	22 percent
Reclaimed water	78 percent

Evaporation from the surface of Indian Creek Reservoir is a factor in water quality. Rates of evaporation in the area are greatest during the period, May to October. At this time the daytime temperatures are highest, leading to a convective rise of air mass up the face of the adjacent Sierra Nevadas which rise to elevations of from 2380 to 2750 meters (7800 to more than 9000 feet). Nighttime cooling of the air mass at higher elevations due to back-radiation through the relatively thin atmospheric cover contributes to a subsidence of cool air at night, resulting in a day to night temperature change which may range from 14 to 22°C (25 to 40°F). Thus although the reservoir is sheltered from prevailing winds, there is a considerable movement of air which scavenges the water surface of its overlying blanket of moist air and so encourages evaporation. Evaporation losses during the four warmest months may average some 61 cm (24 inches), 18 cm (7 inches) of which occurs in July. During the period of study herein reported the annual evaporative loss from Indian Creek Reservoir was estimated at 76 cm (30 inches).

Because of the relatively small percentage of surface water in comparison with reclaimed water and the operating schedule which calls for withdrawing by discharge to irrigation and by evaporative and percolative losses the entire reservoir input each year, it may be expected that the water impounded in Indian Creek Reservoir will resemble reclaimed water more closely as time goes on.

NEED FOR STUDY

Need for the study herein reported has both utilitarian and practical scientific aspects. Inasmuch as the process of tertiary treatment of waste water is far from its ultimate technological and economic optimum, the creation and utilization of Indian Creek Reservoir raised a number of important questions, including:

1. How effective is tertiary treatment at present levels of development in controlling algal growth in impoundments of effluents from such treatment?

2. What limnological developments in impounded tertiary effluents will affect beneficial uses of such impoundments?

3. What degree of treatment would be necessary to permit retention of reclaimed water in the Lake Tahoe Basin without posing a threat to the quality of Lake Tahoe water?

4. Given recreational or other beneficial uses as objectives of water reclamation, what treatment processes are required to produce water of optimum quality characteristics?

Answers to the first two of these questions are badly needed in order to evaluate the processes currently classed as "advanced" or "tertiary" treatment in relation to their objectives.

The third question should be answered because it may not be assumed that tradeoffs between exports from Lake Tahoe via the Truckee River and via pipelines will not some day have to be adjudicated; nor that present social, cultural, and aesthetic attitudes toward reclaimed water will endure forever. Conceivably, water of a quality equal to that of Lake Tahoe may eventually be produced routinely from waste water and be in demand by people living in the Basin at that point in time.

The fourth question is of particular importance in the economic management of the environment. In contrast with the current practice of adding new unit processes to waste treatment as rapidly as they are developed in the belief that the more the treatment the less the pollution, this question envisions the possibility that an optimum balance of water quality factors might be established for the specific beneficial uses desired and waste water treatment processes tailored to produce that desired product.

Interwoven in the need to answer questions such as the foregoing is the need, and the opportunity, to trace the biological and ecological history of an impoundment of highly treated waste water created on previously vegetated dry land. The manner in which such an impoundment matures with time is all important to answering the four questions cited. Moreover, it affords an opportunity never before presented to collect scientific data of exceptional pertinence to the problem of control of eutrophication of surface waters.

OBJECTIVES OF STUDY

The general objective of the study was to collect and evaluate data needed in answering questions such as outlined in the Need For Study. Specific objectives included:

1. To relate the biological, physical, and chemical characteristics of Indian Creek Reservoir to the corresponding characteristics of reclaimed water from the STPUD Wastewater Reclamation Plant.

2. To trace the seasonal and temporal changes in the biological, physical, and chemical characteristics of Indian Creek Reservoir.

3. To relate the observed characteristics of the reservoir water to the nutrient concentrations and biostimulatory characteristics of the influent reclaimed water.

4. To evaluate the relative contribution of biostimulants contributed by the reclaimed water and by exchange from the underlying soil and sediments.

NATURE AND SCOPE OF REPORT

The report herein presented covers work done on the Indian Creek Reservoir pursuant to the objectives of the study during the period December 1, 1968 through May 31, 1971 under Demonstration Grant 16010 DNY. The report draws also upon findings of other cooperating agencies (see Acknowledgments) which are either published elsewhere or included herein in the Appendix.

Because the work was conducted over three consecutive grant periods which ended on May 31 of each year, the data were analyzed and evaluated at the end of each of three study periods (April 1969 through March 1970, April 1970 through May 1971, and June 1971 through April 1974). In preparing this report the results of these three study periods were compared for the reason that filling of the reservoir and acclimating of the newly inundated land occurred during the first year, whereas normal operating plans were in effect during the second; continued maturation of the reservoir continued throughout the third study period and it is primarily that period which is discussed herein. Thus the results obtained during 1969-70 might reveal important limnological factors in the development of the reservoir which might become either more or less critical in the more established impoundment of 1970-74. Such a consideration is especially important wherever averages are used in the report to describe the physical, chemical, or biological responses of the reservoir.

This report draws upon and extends figures and tables previously published in other progress reports [4, 5]. It is a final report summarizing studies from the initial years of the reservoir's existence to the spring and summer of 1974.

SECTION IV

PROJECT DESIGN AND METHODOLOGY

PROJECT DESIGN

The project was designed around a program of sampling, analysis, and evaluation and interpretation in terms of the objectives of the study. The scope and details of the sampling and analytical aspects were designed to determine, within budgetary and climatological limitations, 1) the amount of nutrients entering the reservoir; 2) the effect of such nutrients on the level of productivity of the reservoir; and 3) the environmental fate of these nutrients. It was particularly desired to learn whether nutrients are sequestered in the reservoir sediments or biota, escape to the surrounding environment via the atmosphere, or pass through the reservoir with outflowing water.

Sampling stations were chosen at the locations indicated in Figure 2. Initially, the reclaimed water influent to the reservoir (herein designated by the symbol, III) was sampled at the STPUD plant at the inlet to the pressure outfall line, some 43.5 km (27 miles) from Indian Creek Reservoir. Beginning in July 1969, however, this influent sampling was made at the Luther Pass pumping station (see Figure 1, Section III), some 16 km (10 miles) closer to the reservoir. Discharge from the reservoir (herein designated by the symbol, B) was sampled and measured in rate at a valved outlet pipe in the main dam from which water is discharged in significant amounts during the irrigation season. At other times continuous leakage occurs at a rate of about 57 ℓ/minute (15 gpm) due to poor seating of the valve. By June 1970 it was evident from analytical results that the chemical quality of the discharge (B) was no different than that of the reservoir water because of the high degree of mixing of the impounded water. Therefore sampling of the discharge was discontinued. A composite sample of the impounded water (herein designated by the symbol, C) was made up of several

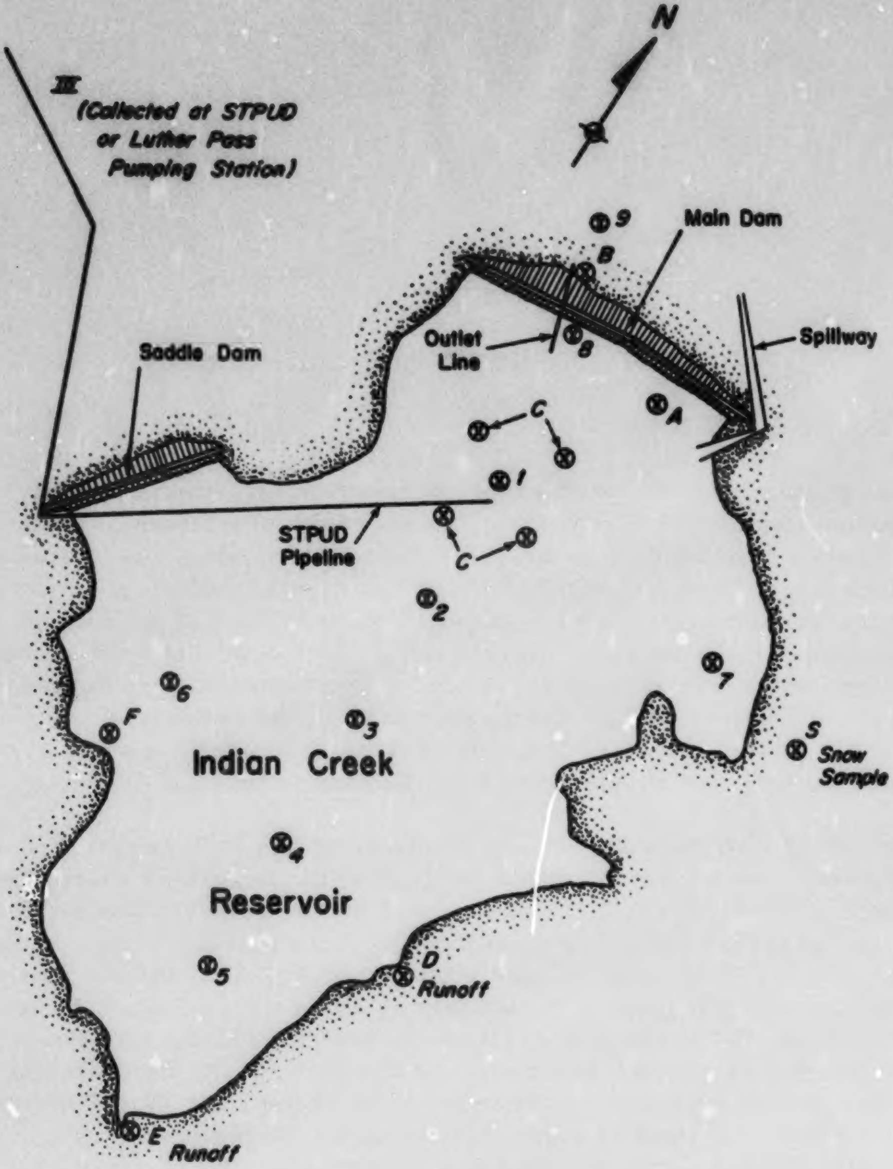

N
III (Collected at STPUD or Luther Pass Pumping Station)
9
B
Main Dam
Outlet Line
8
Spillway
Saddle Dam
C
A
1
STPUD Pipeline
C
2
7
6
F
3
S Snow Sample
Indian Creek
4
Reservoir
D Runoff
5
E Runoff

FIGURE 2. LOCATION OF SAMPLING STATIONS AT INDIAN CREEK RESERVOIR

portions collected around Station 1 (Figure 2). Comparison of analyses of samples from this and other stations in the reservoir showed that Station 1 yielded a good estimate of the levels of nutrients and other constituents of the impounded reservoir water.

SAMPLING PROGRAM AND METHODS

Beginning in April 1969 the influent (III) and composite sample (C) of the reservoir were collected in one-gallon lots (3.8 ℓ) as often as weather conditions permitted, but generally on approximately a weekly schedule. Normally, reservoir sampling was made by use of a trailer-mounted 3.7 m (12-foot) aluminum outboard motor boat. Of necessity this equipment had to be stored at the Lake Tahoe Area Council Laboratory some 96 km (60 miles) from the reservoir, hence when road conditions made transfer of the boat difficult, a one-man inflatable rubber boat was used to collect reservoir samples.

Bottom sediments, benthic invertebrates, phyto- and zooplankton were sampled at intervals to study the aquatic community of Indian Creek Reservoir. A composite sample of the soil from 20 stations around the impoundment was collected in the zone above the water line from which vegetation had been stripped in preparing the site in order to get some idea of the probable organic content of the reservoir bottom initially.

Temperatures were measured using a laboratory thermometer (-10° to 110°C). The Secchi depth was determined as the average point of disappearance for an ascending and descending 20.3 cm (8 inch) diameter white, flat, circular, metal plate. Reservoir depth was read from a staff gage installed at the main dam.

The influent, discharge, and reservoir composite water samples were collected directly in polyethylene bottles used as sample containers. Samples at different depths below the water surface were collected with a plastic Kemmerer sampler and transferred to polyethylene bottles. Bottom sediments were sampled with an Ekman or Ponar dredge. Although rocks and sticks interfered with operation of the dredge in some shoreline areas, it was generally not too difficult to collect adequate lake sediment (as opposed to the soil stratum constituting the reservoir bottom). Usually a depth of 2-5 cm (1-2 inches) of silty-clay was collected at each sampling site. This was screened (U. S. No. 30) when collection and analysis of benthic invertebrates was the objective, or mixed and placed in a sample container for later chemical analysis.

Phytoplankton samples were collected as water samples. Zooplankton were counted directly in water samples or collected by either surface tows (30 m, 100 foot tow near Station 1) or vertical tows (bottom of reservoir to surface) using a Wisconsin Style Plankton net (No. 20 mesh nylon, 117 mm opening) and bucket.

Records of climate and of the flora and fauna observed in the Indian Creek Reservoir Basin were also collected during the sampling trips to Indian Creek Reservoir. For example, wind direction and speed, cloud cover, and unusual climatological conditions were recorded regularly in a permanent log book. Also, visitations to the lake of deer and migratory waterfowl (principally, ducks and grebes) were observed and recorded. The location of developing vascular plant communities, floating algal material, and similar phenomena which would be expected to indicate changes in the reservoir conditions were noted. Data on the developing fish population were obtained, principally from the Department of Fish and Game.

In addition to the regular program of sampling of influent and impounded waters, samples of surface runoff were collected when such runoff was observed. However, because of the dry environment, very little runoff occurred during the summer months. As a rule summer precipitation takes place during a relatively short period of time and is rapidly absorbed or drained into the reservoir. This decreased the likelihood of personnel being on the site to obtain samples when runoff occurred.

Data obtained from studies conducted by the Environmental Protection Agency, the California Department of Water Resources and of Fish and Game, and the South Tahoe Public Utility District were also used to supplement direct observations made by the project staff.

TREATMENT OF SAMPLES

Methods of field and laboratory treatment, as well as storage, of sample were designed to maintain continuity of the work load in the laboratory without sacrificing accuracy of the results of analyses for such characteristics as: DO, COD, BOD, SS, VSS, nitrogen series, orthophosphate, total phosphorus, iron, chlorides, calcium, alkalinity, pH, conductivity, and the biostimulatory properties of various concentrations of the sample.

Water samples were normally transported to the laboratory and stored overnight in a refrigerator ($< 5^{o}C$) for chemical analysis the following day. When it was not possible to begin analysis on such a schedule, the water samples were filtered and the filtrate frozen for analysis at a later time. Analysis for DO and BOD was begun in the field (reagents added up to and including the concentrated H_2SO_4). Initially pH and alkalinity were determined in the field; however, no differences due to the time involved in transporting samples to the laboratory were observed and so all other analyses of the regular weekly water samples were performed in the laboratory.

Phytoplankton were placed in brown glass jars and preserved in the field in a 5 percent Na_2CO_3 neutralized formalin solution. Zooplankton were preserved in 5-10 percent neutralized formalin in brown glass jars. The benthic invertebrates were placed in glass jars after having been screened and rinsed with reservoir water and 15 percent neutralized formalin was added for preservation. Bottom sediment samples were placed in brown glass jars and brought back to the laboratory for later analysis.

ANALYTICAL PROCEDURES

Preparation of Samples

Preliminary preparation of samples for physical and chemical analyses and bioassays varied somewhat depending on the specific method chosen for each assay. Water samples selected for flask bioassays, including Lake Tahoe water used for dilution, were filtered through Whatman glass fiber filters (GF/C) and finally through Millipore® filters (HA, 0.45μ pore size). They were then stored in tightly stoppered polyethylene containers and frozen, unless the test was to begin within five days. For chemical analyses aliquots of the samples, both the unfiltered and those passed through the previously described glass fiber and Millipore® filters, were kept in tightly capped 2-*l* polyethylene containers and stored in a refrigerator at temperatures approaching $0^{o}C$ until all chemical determinations were completed. It was determined that no significant difference existed between chemical analyses of nutrients measured in unfiltered or filtered samples.

Chemical Assays

Chemical analyses of the filtered and unfiltered water samples were made according to Standard Methods [6] in determining biochemical oxygen demand (BOD), chemical oxygen demand (COD), pH, alkalinity, organic nitrogen, ammonia, chlorides, total phosphorus, calcium, and conductivity. Methods described by Strickland and Parsons [7] were considered more suitable for iron, nitrite, nitrate, and reactive inorganic phosphorus at the low concentrations prevailing in the Tahoe samples. Details of individual analyses are presented in Appendix G in [4]. All laboratory chemical determinations were subjected to replicate analyses on aliquots of the same sample [8, 9] to determine the precision of results attainable by the project staff by the analytical procedure used. The results showed that with the exception of organic nitrogen and total phosphorus in Lake Tahoe water, where concentrations are extremely small, the chemical analytical work is of good precision in terms of the coefficient of variation. A statistical analysis of the two methods of laboratory filtration (0.45μ HA Millipore and GF/C Whatman glass fiber filter paper) indicated that there is no essential difference in the accuracy of the two methods.

Sediment chemical composition on a dry weight basis (available P, organic carbon, total N, and particle size) was determined according to methods described by Porcella et al. [10].

The technique for measuring total suspended solids (SS) and volatile suspended solids (VSS) was patterned from a combination of the procedures outlined in Standard Methods [6]; Strickland and Parsons [7]; and Maciolek [11]. Whatman glass fiber filters (GF/C) were used in solids preparation. The filters were prepared by soaking in distilled water to wash the fibers free of salts. They were then placed in a 103°C hot air oven overnight. Thereafter they were placed in a muffle furnace for 30 minutes at 450°C to destroy any organic matter present without fusing the glass fibers. After cooling, the filters were dried in a hot air oven at 103°C and tared quickly on a Mettler semimicro balance, to avoid error due to the hydroscopic nature of the dried filter. In making the solids determinations the sample was applied to the filter until the volume of sample had passed through, or until the filter was completely clogged. The volume of filtrate was then recorded. The filters with their load of suspended solids were dried overnight at 103°C and the dry weight recorded to the nearest 0.01 mg.

To determine the VSS present in suspended solids the loaded filters were then redried and reweighed to verify the SS value. They were then ignited at 560°C for 1 hour, soaked with a few drops of distilled water to rehydrate the mineral matter, dried overnight at 103°C and weighed. The loss in weight was recorded as VSS in mg/ℓ.

In some cases it was necessary to revise the suggested methods in order to expand the scope of the analysis to encompass the wide range of nutrient concentrations encountered in the various samples assayed. The procedure was to prepare two standard curves for the Beckman Model B spectrophotometer, one using a 1-cm pathway cuvette and the other a 5-cm cuvette. The range of concentration for N, P, and Fe using the two pathway cells was from 1 μg/ℓ to 200 μg/ℓ. Samples in which the level of the constituent exceeded the maximum range of concentration were diluted to the concentration range of the cells by a measured volume of deionized water.

Flask Bioassays

Reservoir samples (C) and reservoir influent water (III) were assayed by the flask bioassay technique [8, 9] both undiluted and diluted to 10 percent and 1 percent concentrations in Lake Tahoe water.

In making the assay the filtered sample was first diluted to the desired concentration with filtered Lake Tahoe water. One hundred and fifty mℓ of this solution was then placed in each of three sterile 250 mℓ Erlenmeyer flasks. Glassware used in assays was dry heat sterilized. Cells of Selenastrum capricornutum in good physiological condition were centrifuged and washed twice in Lake Tahoe water to minimize the chance of nutrient carry over from the stock culture to the test flasks. An equal volume of the suspended cells was then added to each test flask, so that the concentrations of cells in the 150 mℓ of liquid was approximately 50 cells/mm^3.

Loose fitting plastic beakers were inverted over the tops of the inoculated test flasks, prior to being placed in a 20°C constant temperature room and incubated on a gently moving (30 cycles/min) shaker table for a period of five days. Illumination of approximately 550 ft-c (5920 lux) intensity was provided by four 40 watt G. E. fluorescent lamps, No. F40-CW, Coolwhite, four ft in length.

The cell concentration in the test flasks was determined by cell counts at the end of 1, 3, and 5 days during the five week period of incubation. After the final counts were completed, suspended solids and pH measurements were made on a composite of the liquid in the five replicate flasks.

The basic culture of Selenastrum capricornutum was maintained at a constant growth rate by the continuous culture method (θ = 5 days) using a nutrient solution of 10 percent Skulberg's medium [12] (Appendix 7).

Algal Counting Procedures

The Model B Coulter counter was used for cell counts. The method used in the Coulter counter technique involved removing a 10 mℓ aliquot from each flask. The aliquot was then diluted with a saline solution so that the final concentration was from a maximum of 50 percent to the concentration that will provide a final count of less than 100,000 particles (counting capacity of the Coulter counter) for a 0.5 mℓ diluted sample. The maximum time required for each count is 13 sec. A mean value was obtained for the five replicate flasks.

Reliability, Sensitivity, and Precision of Cell Counting

The Coulter counter records each time a particle passes between two electrodes. A coincidence correction coefficient is multiplied by the number of particles recorded by the Coulter counter, thereby, providing a statistical correction for the possibility of superimposed cells passing between the electrodes at the same time. Thus it is obvious that the Coulter counter should provide a much higher degree of sensitivity and reliability as well as the added benefit of a considerable time saving over the hand counting technique. The reliability of the Coulter counter was emphasized when the same sample was introduced to the Coulter counter several times in succession and the difference in the numerical results was found to be insignificant ($<<$ 1 percent coefficient of variation).

SECTION V

RESULTS OF STUDY

INTRODUCTION

Pursuant to the objectives and the program outlined in Section III, physical, chemical, and biological observations were made of the progressive changes in the water budget and in water quality in Indian Creek Reservoir (ICR). The results of these observations are hereinafter presented and discussed, and further evaluated in Section VI. The data presented and analyzed were collected by members of the project staff and by the South Tahoe Public Utility District as a part of their normal operating procedures. Estimates by Clair A. Hill and Associates for the STPUD [2] were also used in computing the water budget of the reservoir.

The data for the earlier years of the project are contained in previous reports (April 1968 to March 1970 [4]; April 1970 to March 1971 [5]) and are contiguous with the data presented in this report (April 1971 to October 13, 1974, Appendix 8; graphical presentations are for April 1971 to April 1974 only). Where appropriate, the data from the previous reports are summarized herein. Missing data resulted from interrupted findings, limited access to the sampling sites, or to strong winds which prevented the launching of a sampling boat.

GENERAL OBSERVATIONS

Observations of the reservoir (Table 1) indicate an increase in recreational use, chiefly by fishermen and campers, and in irrigation use because flows of reclaimed water have increased in scale with population increase in the area served by the STPUD. The continued increase

TABLE 1. WEEKLY OBSERVATIONS OF ENVIRONMENTAL DATA, INDIAN CREEK RESERVOIR (JUNE 1971 - MAY 1974)

1	2	3	4	5	6	7
Date	Time of Day (hours)	Secchi Depth (meters)	Water Depth (ft)	Water Temp. (°C)	Air Temp. (°C)	Remarks
Jun 1971						
2	12:00	3.7	53.1	13.5	11.0	Blue, partly cloudy, relocated sta. No. 3 approximately 100' S. in deeper location
14	12:30	2.4	53.1	18.0		Blue, flying insects a slight nuisance near shore
21	12:10	5.3	53.3	18.7	25.0	Blue, approximately 20 fishermen, 4 boats, flying insects still present
Jul						
7	11:30	3.9	53.7	19.8	23.5	Blue, approximately 20-30 anglers, abundant pop. mayflies and night hawks
19	12:35	4.0	53.9	21.1	22.0	Blue, partly cloudy, numerous fishermen, 3 boats, insects still present
26	12:10	5.2	53.9	22.0	21.0	Blue, approximately 20 fishermen fishing reported poor, greenish cast
Aug						
2	13:00	5.2	53.9	23.5	23.0	Blue, partly cloudy, aquatic growth heavy in nearshore areas -- 2 swimmers
9	13:00	3.0	53.9	23.5	29.3	Blue, partly cloudy, approximately six vehicles with fishermen, 1 boat, no water fowl observed
16	12:45	2.0	53.6	21.0	28.0	Blue, partly cloudy, no fishermen, no wildlife observed, strange
23	12:00	3.8	52.9	21.0	24.0	Blue, approximately 18 anglers, one reported a 10" catch, calm
30	12:10	3.7	52.9	20.0	22.1	Blue, large masses floating marine flora
Sep						
7	11:45	3.6	52.0	17.8	20.8	Blue, approximately 25 fishermen, heavy amounts of aquatic growth
16	13:00	4.0	51.5	19.0	22.1	Blue, approximately 35 fishermen, 10 boats, biggest rec. day this season
20	12:00	4.4	51.4	17.0	20.0	Blue, prolific aquatic growth, gusty surface choppy
27	12:00	4.1	51.5	14.5	16.0	Blue, several hundred American Coots in bay
Oct						
4	11:20	5.1	51.7	12.0	19.0	Blue, approximately 11 cars and 3 boats
11	12:50	5.2	51.8	14.0	22.0	Blue, beautiful day, Lake surface glassy
18	1:15	6.0	52.0	11.0	11.0	Blue to partly cloudy, Coot population diminishing
27	11:00	--	--	--	--	Partly cloudy, 50 + mph winds, impossible to launch
Nov						
1	12:15	5.0	52.1	7.0	17.0	Blue, benthic study
8	11:45	5.4	52.3	6.8	12.0	Blue to partly cloudy, extremely green cast, abundant aquatic growth
15	12:10	4.3	52.8	5.0	2.0	Cloudy, ground snow covered, aerators operating
22	11:50	5.3	52.9	4.0	13.0	Blue, fishing season closed 11-15
30	11:45	5.5	53.0	4.0	3.5	Snow, one to 2 inches snow and light snow falling
Jan 1972						
10	11:35	--	--	2.9	9.0	Blue, samples taken through approximately 9" ice, Lake entirely frozen
24	12:15	--	--	3.5	8.2	Blue to partly cloudy, Lake 75% frozen approximately 6" ice, aerators operating
Mar						
27	9:15	4.1	51.0	9.0	1.0	Blue to partly cloudy, aerators operating, several hundred gulls and smaller birds
Apr						
3	11:25	5.2	51.1	10.0	19.0	Blue to partly cloudy, millions of black gnat-like flying insects, aerators operating
10	10:45	--	--	9.0	14.0	Partly cloudy, approximately 40 mph SW wind, too windy to launch, well mixed
17	11:15	4.9	51.6	9.0	9.5	Blue, black flying insects a nuisance, moderate SW winds
25	11:00	6.1	52.0	10.5	13.0	Partly cloudy, deepest secchi thus far, checked by two observers

TABLE 1 (continued)

1	2	3	4	5	6	7
Date	Time of Day (hours)	Secchi Depth (meters)	Water Depth (ft)	Water Temp. (°C)	Air Temp. (°C)	Remarks
May						
1	11:20	6.1	52.1	11.2	17.0	Blue, fishing opening day, 1/4 fish per hour
8	11:20	4.5	52.1	12.0	15.0	Partly cloudy, swallows feeding on flying black insects
15	11:15	2.7	52.1	15.5	22.0	Partly cloudy, approximately 24 fishermen, southerly winds gusting
22	11:45	3.0	52.2	16.2	15.0	Partly cloudy, very calm, 2 boats, 14 anglers
30	11:15	6.6	52.4	19.0	25.0	Blue, no aquatic growth visible, snail population increased
Jun						
5	11:40	5.5	52.4	19.0	21.0	Partly cloudy, aquatic growth now apparent near launch area
12	11:30	4.8	52.5	16.0	22.0	Partly cloudy, very slight northerly causing 2 - 3" ripple
19	11:00	5.0	52.5	19.2	22.0	Blue to partly cloudy, 4 boats, 8 cars, approximately 12 fishermen, 2 motorbikes
26	11:00	4.5	52.5	19.2	24.0	Partly cloudy, slight northerly, 2 boats, 12 fishermen
Jul						
5	11:10	4.9	52.5	21.5	27.0	Blue, strong southerly, white caps, well mixed
10	11:20	3.2	52.3	20.0	26.5	Blue, reservoir level down 0.2'
17	11:00	4.5	51.8	22.0	26.0	Blue, prolific aquatic growth breaking surface
25	11:00	3.1	51.0	20.0	24.0	Blue, approximately 24 anglers, 1 1/4 fish/hr reported
31	11:25	3.3	50.5	21.0	24.0	Blue to partly cloudy, large masses of marine flora near shoreline area
Aug						
8	11:15	4.3	47.5	21.2	22.0	Partly cloudy, marine flora now extending approximately 30' around entire perimeter
14	11:40	3.4	47.2	19.2	17.0	Blue, brisk southerly, wave 4 - 6", 3 fishing boats
21	11:10	4.7	46.0	18.2	19.5	Partly cloudy, STPUD harvesting aquatic growth with mechanical sickle device
28	11:05	5.5	44.2	19.0	19.0	Partly cloudy, BLM Const. crews working on South perimeter road to California
Sept						
5	11:10	6.6	42.3	18.0	19.5	Cloudy, rain, cutting discontinued, aesthetically unsuccessful
11	11:15	4.4	42.0	16.9	14.0	Partly cloudy, STPUD unsuccessfully trying to burn aquatic debris
18	10:55	6.6	41.4	16.0	16.0	Partly cloudy aerators operating approximately 10 fishermen mostly in boats
25	11:22	6.8	41.9	14.0	10.0	Blue to partly cloudy aquatic growth near shore very prolific, 7 fishermen
Oct						
2	11:25	7.3	43.0	13.2	13.0	Cloudy, large population of American Coots, several hundred
9	11:45	4.4	43.1	14.0	15.5	Cloudy, 3 boats, 10 anglers, benethic study made, aerators not operating
16	11:45	5.5	43.2	12.0	8.0	Partly cloudy, BLM Contractors working on recreation facilities
20	11:05	6.0	43.7	10.8	7.0	Cloudy, bacteriological survey conducted with Don Porcella
30	11:25	5.4	44.1	8.7	4.0	Partly cloudy northerly wind gusting wave 2 - 4", 2 boats
Nov						
6	11:30	3.7	44.5	7.9	7.1	Partly cloudy, SW wave 5 - 8", 2 boats, 4 cars
13	11:45	3.5	44.8	5.9	7.0	Cloudy, snow, wind from S approximately 25 - 30 mph, approximately 100 Coots 2 fishermen
20	11:05	6.1	45.2	4.5	3.0	Blue, aeration greatly improved, BLM Contractors out for winter
27	10:45	7.3	45.7	3.9	4.5	Blue, elec. into aerators, Coots still abundant, calm, glassy

TABLE 1 (continued)

1	2	3	4	5	6	7
Date	Time of Day (hours)	Secchi Depth (meters)	Water Depth (ft)	Water Temp. (°C)	Air Temp. (°C)	Remarks
Dec						
5	12:30	Ice	--	2.5	3.0	Partly cloudy, approximately 15% frozen with 1/2 to 1 1/2" ice, 2 - 3" snow
11	11:30	Ice	--	1.0	-11.2	Blue, approximately 3" ice covering 99% Lake, 6 - 8" snow
26	11:12	Ice	--	2.0	5.5	Partly cloudy, blue, approximately 75% frozen with 1" ice, open over aeration lines
Jan 1973						
2	11:05	Ice	--	2.0	5.2	Blue, approximately 85% frozen, 1 to 1 1/2", road slippery, strong southerly
8	10:50	Ice	--	2.0	2.0	Cloudy, 65% frozen, 1 1/2 to 2 1/2" ice cover, snow expected
15	11:15	Ice	--	2.5	8.0	Blue, partly cloudy, 50% frozen with less than 1" ice, mixing
22	11:40	Ice	--	2.5	0.0	Blue, 85% frozen, approximately 1 dozen birds nesting on the ice
29	11:30	Ice	--	3.0	1.0	Cloudy, snow, 80% frozen approximately 1" of snow on ground
Feb						
5	11:30	Ice	--	2.2	2.8	Partly cloudy, 1/2 to 1" ice covering 75% surface
13	11:30	Ice	--	4.5	5.0	Blue, 70% ice cover, approximately 12" snow, road not plowed
20	11:45	Ice	--	7.0	5.0	Blue, 50% ice, road extremely muddy
26	11:20	Ice	--	7.1	10.0	Cloudy, 40% ice, 35 mph wind, flock of water fowl
Mar						
5	11:34	Ice	--	4.1	6.0	Blue, 30% ice cover, PUD aerating with 90 psi compressor
12	11:45	--	--	6.5	6.8	Cloudy, completely unfrozen, PUD aerating at launch
19	10:55	--	--	7.2	9.1	Cloudy, 1 to 2" wave, 3 cars, 4 fishermen, 1 boat
26	11:15	1.2	54.5	6.2	12.0	Blue, partly cloudy, 4 vehicles, 8 fishermen, fish jumping apparently under stress
Apr						
3	11:10	--	--	8.0	11.0	Partly cloudy, slight northerly, PUD aerating with portable unit
9	11:35	1.6	55.0	9.5	13.9	Cloudy, approximately 26 fishermen, flying gnat-like insects a problem
16	11:30	--	--	10.2	9.0	Partly cloudy, 20 mph winds SE, approximately 12 fishermen, PUD aerating
23	11:15	8.7	55.7	10.8	14.8	Blue, approximately 20 vehicles, 4 campers, green filamentous algae
30	11:10	7.6	55.9	12.1	13.0	Partly cloudy, overnight campers, several [illegible] swallows diving at surface
May						
7	10:50	7.6	56.0	14.0	16.0	Blue, approximately 28 fishermen, slight northerly breeze
14	11:15	6.0	56.3	15.0	17.3	Blue, partly cloudy, approximately 6 rec. vehicles, mayflies hatching
21	11:20	4.5	56.5	16.5	16.2	Blue, noticeable burnt odor near North dam, floating clumps algae
28	11:55	4.5	56.3	17.2	18.8	Blue,approximately 50 fishermen, 17 boats, 49 boats previous Saturday
Jun						
4	10:50	2.0	56.3	17.0	13.2	Blue, floating algal clumps East of boat launch
11	11:30	4.9	56.6	19.5	19.0	Partly cloudy, northerly wind, 8 - 10 mph, approximately 18 fishermen
18	11:20	5.4	56.4	17.2	14.5	Blue, approximately 16 vehicles, 24 fishermen and 6 boats
25	11:05	4.9	56.3	18.5	19.6	Blue, approximately 10 fishermen, abundant snail population, floating algae
Jul						
2	11:40	5.3	56.4	19.0	23.0	Blue, brisk SW wind, approximately 24 fishing, 4 boats, 9 rec. vehicles
9	11:10	4.3	55.9	21.0	22.0	Blue, increased algal blooms near boat launch
17	11:30	4.5	54.0	21.0	20.5	Partly cloudy, approximately 10 boats, 24 fishermen, 4 rec. vehicles
23	12:30	4.7	52.8	20.2	24.6	Blue, winds from S at 3 to 5 mph, wave 3 to 6"

TABLE 1 (continued)

1	2	3	4	5	6	7
Date	Time of Day (hours)	Secchi Depth (meters)	Water Depth (ft)	Water Temp. (°C)	Air Temp. (°C)	Remarks
Aug						
6	11:20	5.7	51.0	21.5	28.0	Blue, partly cloudy, extremely warm water level going down rapidly
13	12:20	6.1	49.1	20.2	22.9	Blue, wind gusting to 10 mph, wave 3 to 6"
20	11:45	5.5	48.0	19.5	19.0	Blue, southerly winds to 20 mph
28	11:10	7.3	45.8	17.0	18.9	Partly cloudy, 2" snow fell on Luther Pass, 24 fishermen, Coots
Sept						
4	11:00	6.2	44.6	17.0	19.2	Blue, winds from N, wave 3 to 5", 3 boats
10	11:00	5.2	42.6	17.0	11.8	Blue, partly cloudy, 14-16 anglers, 7 boats, slight southerly
17	11:31	5.7	40.9	17.2	19.5	Cloudy, PUD dragon harvesting, aquatic weed growth
24	11:15	--	41.3	15.3	12.7	Partly cloudy, strong (35--45 mph) S.W. winds, too windy to launch
Oct						
1	11:30	≥6.7	41.9	14.0	18.4	Cloudy, Secchi resting on bottom still visible
8	11:10	6.0	42.0	11.2	8.9	Cloudy, southerly, large population of Coots
15	11:00	6.6	42.6	16.0	18.5	Partly cloudy, 4 fishermen, 3 cars, southerly winds
22	11:05	--	43.0	12.2	14.1	Partly cloudy, brisk southerly 18" white caps, no launch
29	11:05	6.7	43.6	10.0	8.5	Blue, slight N. wind, wave 1 - 2", small flock of Coots
Nov						
5	11:40	3.7	43.9	6.4	13.9	Cloudy, large increase in Coot population, southerly at 20 mph
13	10:40	--	--	7.5	6.4	Cloudy, strong SW wind 30 -- 35 mph, no launch
19	11:45	9.2	45.1	6.2	4.0	Blue, calm, road muddy, Coot population into thousands
26	12:00	--	--	5.0	3.1	Partly cloudy, 1/4" ice around shallows, light snow, calm
Dec						
4	11:50	--	--	--	1.0	Partly cloudy, 15% ice cover 1/2 to 3/4", no inflow due to power outage
10	11:20	--	--	7.1	11.1	Blue, 20% ice aerators operating, road muddy
17	11:45	--	--	4.0	8.4	Cloudy, strong SW, Coot population diminishing
26	11:30	--	--	4.0	11.0	Cloudy, thin layer ice, early a.m. broken up by wind
Jan 1974						
14	11:45	--	--	4.0	3.5	Cloudy, approximately 60% frozen, 2 fishermen, no wind
21	12:05	--	--	6.0	1.5	Partly cloudy, no ice cover, approximately 1" new snow, 4 fishing
28	11:15	--	--	6.5	9.1	Blue, slight SW wind, no ice, approximately 6 fishermen

TABLE 1 (continued)

1	2	3	4	5	6	7
Date	Time of Day (hours)	Secchi Depth (meters)	Water Depth (ft)	Water Temp. (°C)	Air Temp. (°C)	Remarks
Feb						
4	11:15	--	--	5.9	7.2	Blue, slight SW wind, catch 3 - 18" rainbows 3 to 4 lb in 1 hr
11	11:15	--	--	5.5	12.0	Blue, southerly wind gusting to 20 mph, 12 to 16" whitecaps
20	11:10	--	up	5.3	1.5	Blue, no ice, 2" snow, level up considerably
25	11:30	--	--	9.0	13.0	Partly cloudy, brisk SW, 4 vehicles, 8 to 10 fishing, no snow or ice
Mar						
4	12:30	--	--	8.1	8.0	Blue, 8 to 10" new snow, slight NW wind, snowshoe into reservoir
12	11:15	--	--	7.1	8.2	Partly cloudy, SW winds gusting to 40 mph, whitecaps to 16"
18	12:00	5.2	54.6	6.3	12.0	Cloudy, no wind, boat launched, water very green, 4 fishing
25	11:00	--	up	8.2	6.1	Cloudy, snow, wind southerly at 10 mph, fishing poor
Apr						
2	12:00	--	up	9.0	2.0	Partly cloudy, slight southerly, large flock black birds
8	11:15	--	up	10.0	9.8	Blue, partly cloudy, strong southerly gusting to 50 mph, 20" wave
15	11:40	--	up	10.1	8.2	Blue, strong winds from south, whitecapping
22	11:15	--	up	13.1	9.2	Partly cloudy, strong southerly, overnight campers, soaring gulls
29	11:10	3.3	57.0	11.2	10.0	Partly cloudy, approximately 20 anglers, mass of floating clumps, soaring gulls
May						
6	11:25	6.1	57.0	13.0	14.5	Blue, approximately 16 anglers, approximately 40 gulls, mayflies hatched, slight north wind.

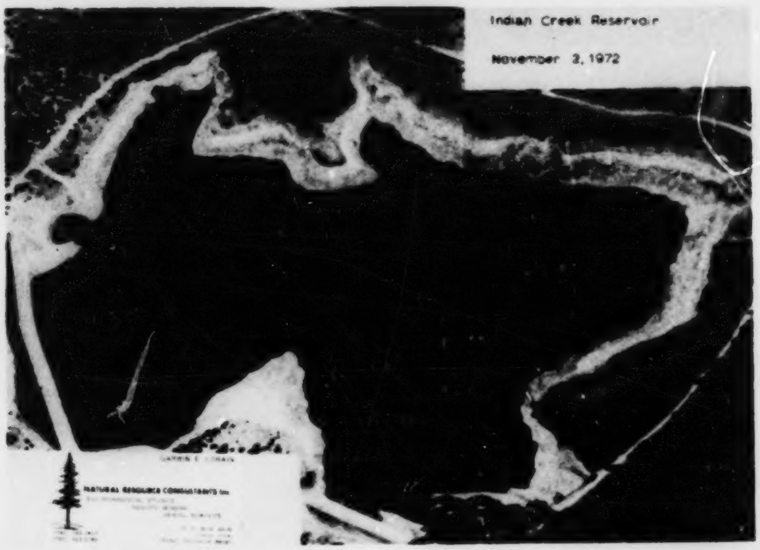
in aquatic weed growth with aging of the reservoir has been a major observable trend.

Simple quantitative methods for heterogenous and complex systems often are incomplete and photographs can convey better understanding of the total system than other kinds of measurements. The aerial photograph (Figure 3) was taken to illustrate the accumulated aquatic vegetation in littoral areas of the reservoir at the low water mark in reference to the high water mark as of November 2, 1972 (see Figure 2 for schematic description of reservoir). The dirt road can be clearly seen as it circles the lake. Also there is a sharp outline of the water's edge as well as the greyish border of grass above the shoreline as it meets the white of the exposed lake bottom (Figure 3A). The aquatic weeds (Figure 3B) show up as greyish areas in the shallows of the lake.

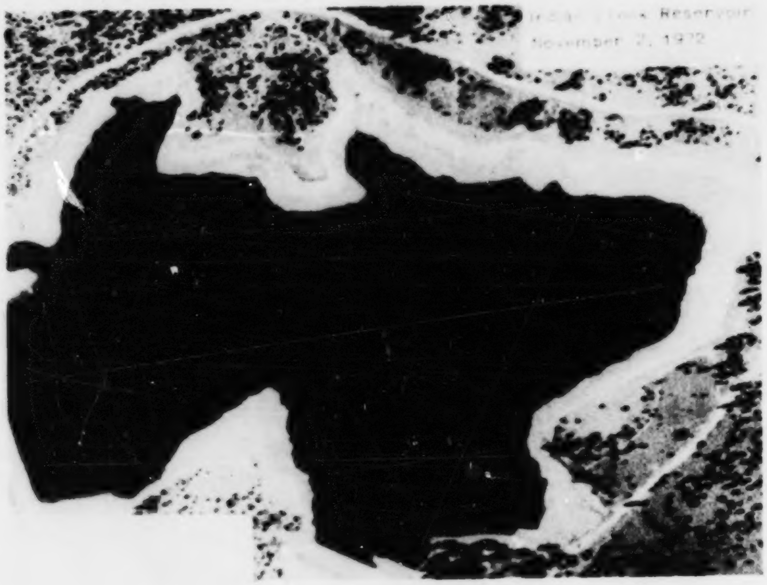
The picture (Figure 3) illustrates a segment of the typical ICR annual cycle, i.e., attaining the low water volume during the fall as a result of the irrigation season. The reservoir fills during the winter months. Thus, as spring begins and water is discharged for irrigation, aquatic vascular plants begin to bloom in shallow areas. These weeds are limited in their areal expansion most probably by light intensity. Higher turbidity with the spring phytoplankton bloom and other suspended solids interferes with light transmission (refer to Secchi disc measurements in Figure 4) and restricts weed growth to shallow water areas along the edge of the reservoir. This is followed by increased water clarity hence light transmission during the early summer months allows penetration of weed growth into deeper waters.

Irrigation water use causes a marked decrease in water level leaving banks of weeds dying on the exposed shores but also allowing expansion of the weed population into deeper waters. This pattern allows expansion of the aquatic weed community to expand into deeper waters and cover greater areas of ICR each year.

Reservoir management practices at ICR began with the installation of aeration apparatus in 1970 for destratification purposes. Aeration has been more or less continuous, maintaining relatively isothermal conditions but not saturation with DO nor biological mixing; biological populations of plankton remain unevenly distributed.


Indian Creek Reservoir
November 3, 1972
NATURAL RESOURCES CONSULTANTS Inc.

A. Color photograph in black and white; north to south reads left to right.


Indian Creek Reservoir
November 2, 1972

B. Infrared in black and white. Note plant growth in shallow south area and along west shore.

Figure 3. Composite aerial photographs of Indian Creek Reservoir, November 2, 1972.

In the summer of 1972 aquatic weeds became a significant nuisance in ICR and a rented mechanical weed harvester was used to remove some of the shoreline growth; burning of the dried, exposed weeds was also undertaken as a means of control but apparently had little effect on weed growth during the following years. The rented harvester was utilized again in summer, 1973; in summer, 1974, beginning after July 4 and finishing about the middle of August. A harvester, the "Dragon," designed and built by STPUD was utilized for harvesting and reportedly removed more than 300-400 cubic yards of plant material from ICR [13]. The effects of this harvesting were not readily apparent at the time of this reporting (September 1974). A diminution in ICR nutrient concentrations occurred but weeds were still abundant in September 1974 and interfered with bank fishing. At that time weeds had covered a larger area of the reservoir as the water level dropped during the summer irrigation season.

During the latter half of summer 1974 a significant population of blue green algae, *Oscillatoria* (*rubescens*) was observed growing on detached *Cladophora* clumps and on attached weeds, principally *Myriophyllum*. The blue green algae imparted a significant earthy odor [14] which apparently tainted the fish flavor in addition to producing a strong shoreline odor observed by the project staff on September 4, 1974. It is unclear what conditions influenced the development of the large bloom of this alga.

Insects flying around the lake and over its surface are plentiful in summer and include damselflies, dypterans and mayflies. Bird populations vary chiefly with the migratory season.

Weather conditions at ICR remain fairly typical; brisk winds and breezes occur in the fall through winter and during mid-day (11 a.m. to 3 p.m.) during summer. Clear skies are more common during the summer when minimal precipitation occurs.

Wind direction seems to be heavily influenced by the adjacent mountain range, with southwesterly or northwesterly winds most common. Only on rare occasions was the water surface free of ripples or waves due to wind, a fact which undoubtedly reduced the clarity as measured by the Secchi disk. The roughest water observed resulted from strong southwesterly winds in October and December, and from northerly winds in March.

Wind movement across the reservoir undoubtedly has an important effect on mixing of the reservoir. From Figure 2 (Section IV) it may be seen that a southerly wind roughly parallels the long axis of the reservoir, moving from the shallowest water towards the dam. Waves induced by such wind action then tend to stir up sediments in the shallows and, if of any duration, to pile up water at the deepest end of the reservoir. Subsequent movement of water is therefore from the reclaimed water inlet (near the dam) to the shallow southerly end of the pool. A northerly wind, of course, develops a seiche that results in a return flow to the dam when calm is restored. Southwesterly winds blow toward the lake shore northeast of the dam (see Figure 2) and, because of the protection of a high ridge at the west abutment of the dam, can be expected to initiate a counterclockwise movement of the surface water in the reservoir. This should have a mixing effect, at least in the deeper portion of the impoundment north of an east-west line passing through the saddle dam. It is concluded that the well mixed condition found to exist in Indian Creek Reservoir is to no small degree a result of wind movement and direction.

Water Budgets of ICR

Because the chief purpose of this report is to catalog biological changes with respect to reservoir maturation, chemical changes, and biological succession, analysis of hydrologic events is limited to a brief review of data in previous reports (4, 5) and to a brief analysis and listing of recent flows into ICR from STPUD (see Appendix 6).

Filling of Indian Creek Reservoir was begun on March 31, 1968. Table 2 summarizes five 12-month periods (April through March, 1969-1974) in developing a water budget for Indian Creek Reservoir. The values for use in the water balance equation, $E + P_o = I + RO + P_L - D - V_o - \Delta S$, were estimated as hereinafter outlined. Definition of each symbol in the equation is noted in column 2 of Table 2.

An obvious development with time has been the increase in flow from STPUD into the ICR system and the increase in use of the reclaimed effluent as irrigation water. The reclaimed water inflow is not yet equivalent to that estimated in the planning study (see Appendix 2).

Evaporation from the reservoir surface (E) was computed from the reservoir water surface corresponding to the average gage height observed for each month of the year, multiplied by the average

Table 2. ESTIMATIONS OF ANNUAL WATER BALANCES FOR INDIAN CREEK RESERVOIR [SEE 4, 5 FOR METHODS]

Symbols for Water Budget Equation	Explanation	Volumes and Flows During Period of Estimation, m^3 (ac ft)					
		Apr. 1969 Mar. 1970	Apr. 1970 Mar. 1971	Apr. 1971 Mar. 1972	Apr. 1972 Mar. 1973	Apr. 1973 Mar. 1974	Total 4/69-3/74
I^a	STPUD reclaimed water influent (+)	2674	2687	3021	3184	3608	15174
RO	Sub-basin drainage into ICR (+)	1145	815	723[d]	728[d]	727[d]	4138
P_L	Precipitation on ICR surface (+)	340	225	229[d]	213[d]	270[d]	1277
E^b	Evaporation from reservoir surface (-)	387	450	368	309	322	1836
P_o^c	Percolation through reservoir bottom (-)	2426	1375	1051	1864	846	7562
D^a	Discharges (-)	522	2448	2530	1640	3413	10553
V_o^e	Leakage through ICR outlet (-)	24	24	24	24	24	120
ΔS	Change in volume of water impounded during period of calculation (±)	+800	-570	+200	+288	0	718

[a] Data released from STPUD [15].

[b] Based on Clair Hill Associates data [2].

[c] Estimated from assumed water balance; see [4, 5] for methods.

[d] Based on average annual rainfalls; Woodfords Precipitation Station Closed [see 2, 4, 5].

[e] Estimated using a single measurement of 15 gpm.

evaporation rate for free water surfaces in the Indian Creek area for the corresponding month. Depth-Area and Monthly Evaporation Curves developed by Clair A. Hill and Associates [2, 4, 5] were used in this computation (see Appendix 4).

Precipitation on the ICR drainage area, and directly on the reservoir surface (P_L), was taken from the U.S. Weather Bureau records at Woodfords which shows 28.02 inches for the 1969-70 12-month period. For the 1970-74 period the long-term average value of 20 inches [2, 4] was used; the Woodfords station is no longer operating.

Runoff (RO) was computed from monthly precipitation values (observed or average) multiplied by monthly runoff factors estimated by Clair A. Hill and Associates [2, 4]. However, the estimated annual input to the reservoir from runoff and direct precipitation is decreasing ranging from 34 down to 22 in 1974, as compared to the anticipated average annual value of 30 percent (Appendix 2).

Leakage through the reservoir outlet (V_o) was determined by measurements made by the project staff, which showed about 15 gallons per minute as an average value.

Percolation losses through the reservoir bottom (P_o) were obtained by differences, using the water balance equation. Thus the value for percolation reported in line 5 of Table 2 represents actual percolative losses from the reservoir, plus or minus the net error in assumption in evaluating other items in the water balance equation. In exploring the inherent error resulting from the foregoing approach it was previously reported [4] that during the summer months of 1969-70 the apparent loss of water by percolation was around 0.035 feet of water per day. Such a value has been shown [16] to be within the range which might be expected in tight soils continuously inundated for more than a year. The apparent percolative loss rates for the full five year period (assuming an annual average area of 135 acres) was 0.048, 0.028, 0.021, 0.038, and 0.017 feet of water per day for each of the years 1969-1974, respectively. None of these values take into consideration the greater percolative capacity of soils that are drained when the depth of water in the reservoir is decreased during discharge--a refinement that is impossible to achieve with the available data. Nevertheless, the values are reasonable and consistent with the well-known fact that the rate of infiltration into a continuously inundated soil decreases with time. Consequently in very rough terms the percolative rate results appear to support the general conclusion that the water balance shown in Table 2 is a reasonable estimate.

PHYSICAL PARAMETERS OF ICR

Such detailed data as clarity (Secchi depth), air and water temperature variations throughout the day and with depth below the water surface are of particular importance in evaluating the quality of water in the reservoir and its relationship to observed biological changes. In the context of the physical characteristics of the reservoir, however, Table 1 is adequate to reveal the magnitude and variation in water and air temperatures, and in the clarity of the water as measured by the Secchi disk.

Clarity of Water

During the period May 1969 to May 1971 the clarity of the water in Indian Creek Reservoir varied from 0.8 to 6.5 meters (2.3 to 21.5 feet). As the reservoir became more mature there was a marked tendency for the clarity to increase. For example, during 1969 the maximum clarity occurred in December when the Secchi disk reading exceeded 3.4 m. However, in 1970 values in the5.8 to 6.4 meter range appeared in April and July, and again in the October to December period. In both years a period of high clarity appeared in the month of July, with minimum values occurring in February and March. It is difficult to document the exact causes of the winter decline in clarity. The greatest surface runoff occurred in winter. This might be expected to bring in appreciable suspended solids from surface wash. Considerable algal growth occurs in the February-March period, giving a green cast to the water and quite obviously reducing its clarity.

In the years since 1972 the reservoir has remained in a relatively stable pattern of low clarity during the months of February and March, with a trend to high clarity during April, May, and June, decreasing to intermediate values in July and August and reaching high clarity during September, October and November (Table 1). December and January measurements were seldom obtained because of thin ice cover and winds which interfered with boat launching. The maximum Secchi depth of 8.7 m (28.5 feet) was observed on April 23, 1973.

A possible explanation for the observed pattern of water clarity is that algal blooms developing in late winter are removed by increased zooplankton (Daphnia magna and other herbivores) grazing as water temperature increases during the spring. Summer winds increase the turbidity of the lake by mixing which affects deeper sediments as the lake level falls due to irrigation use. Fall clarity increases as less phytoplankton grow in the lake due to decreasing light intensity. In general the clarity of ICR was typical of shallow impoundments of good quality water.

Temperature

From Table 1 it is evident that water temperature in the surface zone followed ambient air temperature in a normal manner, with less response to transient climatological phenomena. Of greatest significance to the water quality and biological productivity of the reservoir is the fact that the near-surface water temperature maintained levels in the 18-22°C range over essentially a four-month period each year. Figure 4 shows that the water temperature pattern was essentially repeated for each year studied. Data presented in Appendix 8 show that some (> 1.0°C) thermal stratification was evident from late May to mid-July. In September there was little (< 0.5°C) temperature difference between the surface sample and the sample 1/2 meter off the lake bottom, indicating good vertical mixing. That this was not simply the effect of the aeration turnover system is evidenced by the thermal profile which existed in previous months under similar aeration.

CHEMICAL OBSERVATIONS - MACROCONSTITUENTS

Daily observations of the chemical and bacteriological quality of reclaimed water exported to Indian Creek Reservoir by the South Tahoe Public Utility District were compiled by the District from the beginning of export March 31, 1968 and reported on a monthly basis thereafter. Analyses of the impounded water were begun by the LTAC Laboratory on October 3, 1968, prior to the beginning of the EPA Indian Creek Reservoir Demonstration Grant, as a part of ongoing studies of eutrophication of surface waters likewise supported by the EPA [17]. Beginning in April 1969, analysis of the exported reclaimed water was made also by the LTAC Laboratory as a part of its weekly sampling program at Indian Creek Reservoir [4, 5]. Analysis of surface and ground waters in the vicinity of the reservoir made by the California Department of Water Resources have been reported [see 4].

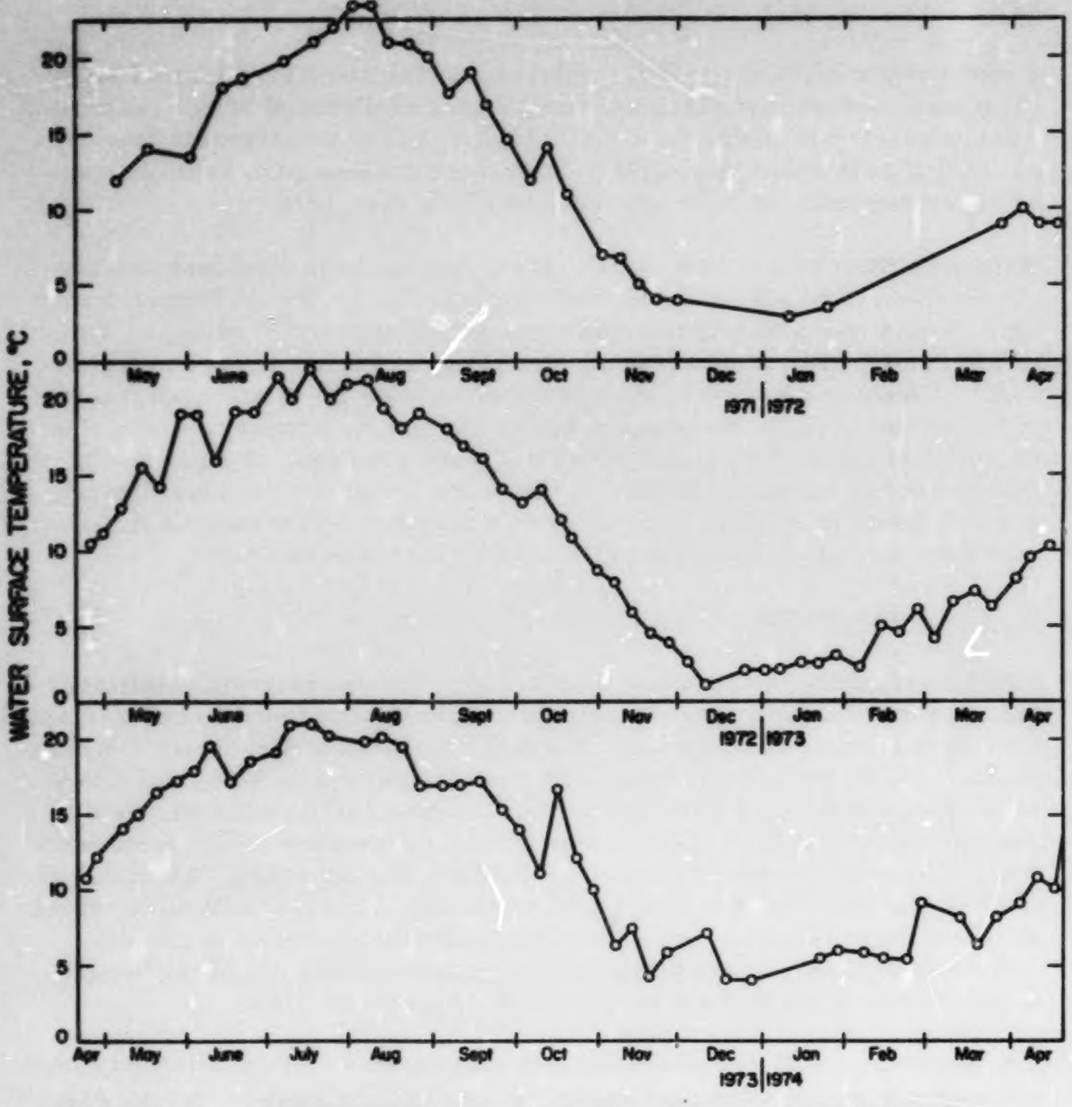


FIGURE 4. TEMPERATURE, INDIAN CREEK RESERVOIR

COD

From results of BOD analyses obtained during the first year of study [4] it was evident that the Biochemical Oxygen Demand of the reclaimed water exported to Indian Creek Reservoir (III) was extremely low, averaging only about one mg/ℓ. Therefore routine BOD examinations of reservoir influent were discontinued in March 1970.

Values of COD as a measure of organic matter in the influent and impounded water of ICR are reported in Appendix 8. From Figure 5 it is evident that there was little difference in influent and impounded water in terms of COD; influent waters have slightly higher concentrations of COD. There is, however, a slight tendency for the impounded water to be higher in COD, especially during the spring growing season when, as noted in relation to clarity (Table 1), the presence of algae in the impounded water was evident. Some of the influent COD must decompose as there is a slight decrease from influent levels and the impounded water also contains algal cells which contribute to COD.

Suspended Solids (SS)

Previously, SS was related to clarity [5]. The correlation coefficient for suspended solids versus reciprocal clarity was found to be 0. 88 and the regression coefficient was 25 ft. mg SS/ℓ Secchi disk depth. When the data on SS were segregated into two groups (> 50% VSS, and < 50% VSS) it was found that although the correlation coefficients were comparable (0. 93 and 0.87, respectively), the regression coefficients were quite different, varying from 31 ft. mg SS/ℓ for the > 50% VSS material to 21 ft. mg SS/ℓ for the < 50% VSS material. Thus considerable effect of the presence of algae as VSS on the relationship between SS and Secchi depth occurs, probably because of the absorption of the longer wave lengths of light (red) by the chlorophyll in the algae.

The variation in SS concentrations in reclaimed water is relatively constant except for an occasional peak (Figure 6). The peak values (nearly 10 mg/ℓ) are about double the peak values presented previously [5]. The excess of SS in impounded water over that in reclaimed water is most impressive in the early growing season (January to April) of each year. The effect of climatological factors on the suspended solids in the reservoir is evident in the data for September through November, particularly in 1973. Strong winds are largely responsible for the high SS values during that time (see clarity data in Table 1).

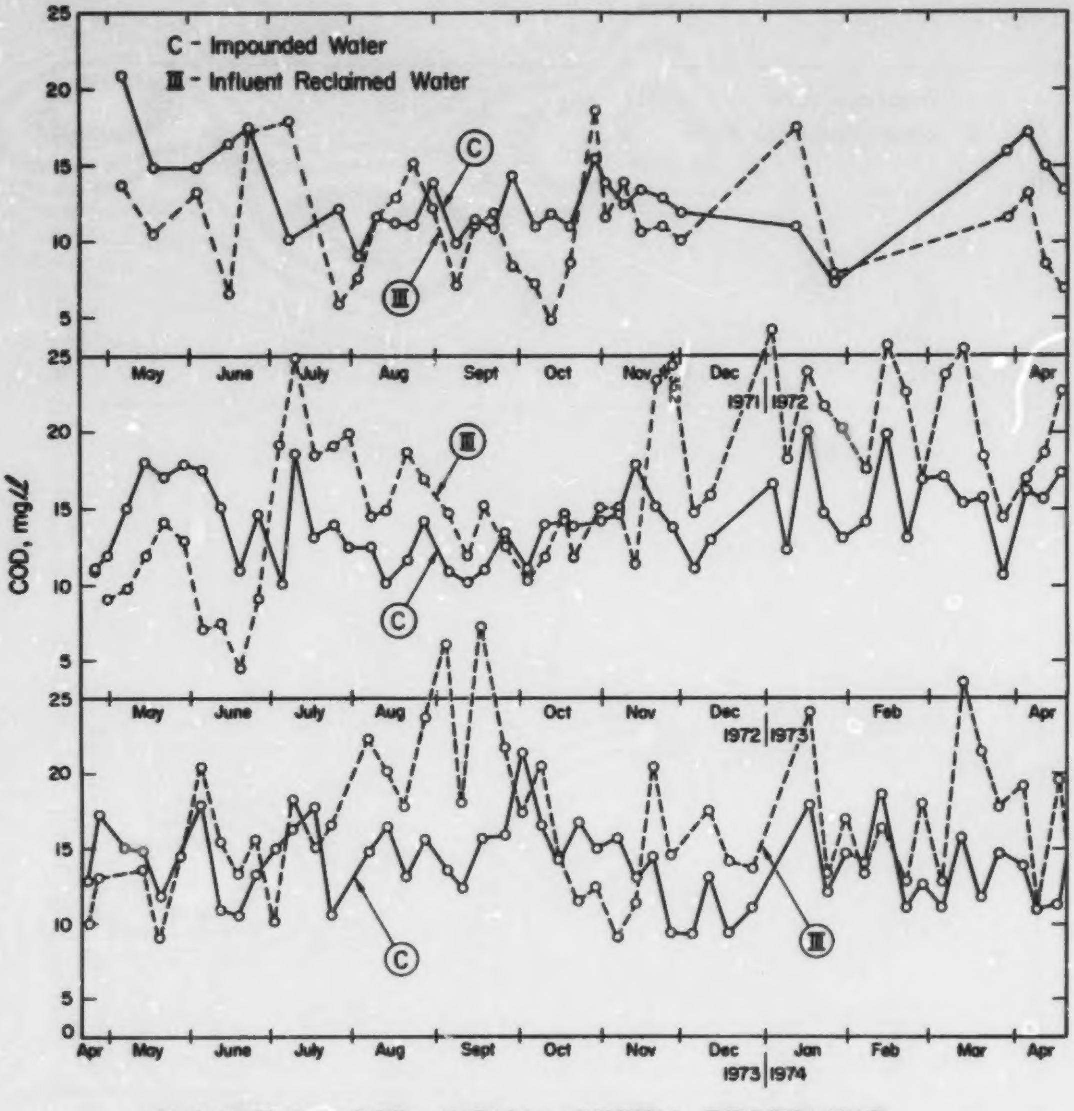


FIGURE 5. COD, INDIAN CREEK RESERVOIR

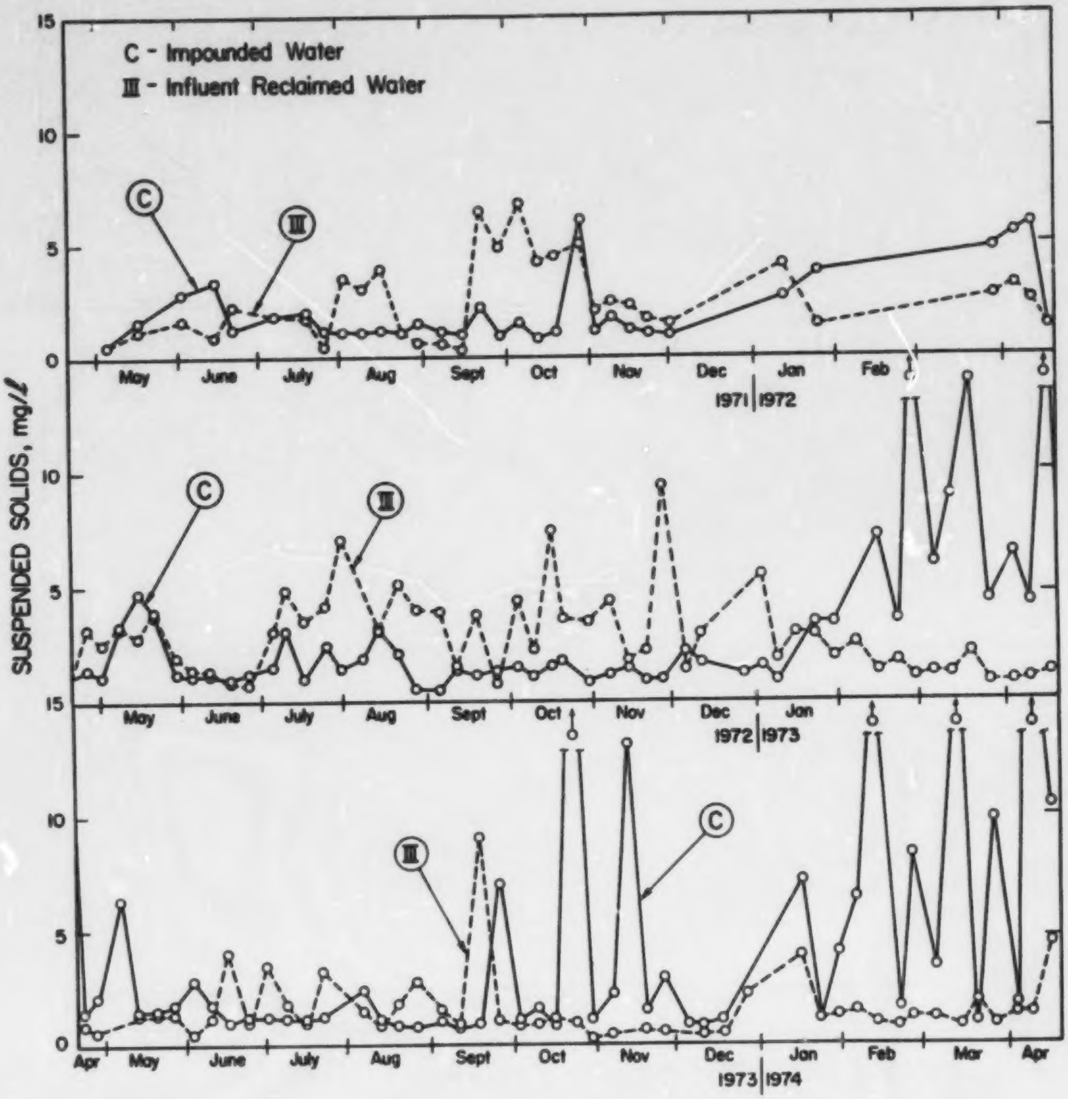


FIGURE 6. SUSPENDED SOLIDS, INDIAN CREEK RESERVOIR

Volatile Suspended Solids (VSS)

Figure 7 shows a tendency for the VSS in the impounded water to be like that of the influent reclaimed water except during the spring growing season and on a few other less obviously explainable occasions. Thus VSS, as might be expected in a situation such as Indian Creek Reservoir, tends to follow the same pattern as the total suspended solids (SS). A comparison of Figure 7 with Figure 6 shows this generally to be the case. Peak values of SS seem to be associated with winds while VSS values peak during bloom conditions. Inasmuch as wind conditions at Indian Creek Reservoir are unpredictable and no continuous wind records are available, and the VSS levels involved are only in the 1 to 2 mg/ℓ range, there is nothing implausible about the observed variation in SS/VSS ratio although its causes are not fully identified.

Chlorides

Previous results show that the chloride concentrations of the reclaimed water generally exceeded that of the impounded water prior to about September 1970 as the reservoir was filled and became somewhat stabilized [5]. In September the two were essentially equal and remained so until the spring of 1971 when the impounded water concentration curve became slightly the higher of the two. In numerical terms the chloride concentration of influent reclaimed water averaged 27 mg/ℓ during the first period (April 1969 through March 1970), and increased to 29 mg/ℓ (April 1970 through March 1971), 32.4 mg/ℓ (April 1971 through March 1972), 35.8 mg/ℓ (April 1972 through March 1973), and 39.3 (April 1973 through March 1974). Peak values were observed during October and November and increased from 29.9 mg/ℓ (October 1969), 32.4 mg/ℓ (October 1970), 40.0 mg/ℓ (November 1971), 42.4 mg/ℓ (October 1972), to 47.8 mg/ℓ (November 1973); illogically high values were excluded. The incremental percent increase in chloride concentration for each year following the first year (April 1969 through March 1970) was 7.4, 11.7, 9.5, 10.9. The average increment over the four years was 9.9 percent per year; the calculated evaporation rate (1449 evap/16030 inflow from Table 2) over the same four years was 9 percent. Thus, the increase in chlorides apparently results from the concentrating effects of evaporation with time.

In general the trends in chloride concentration with time support the idea that evaporation will increase chlorides and other conservative

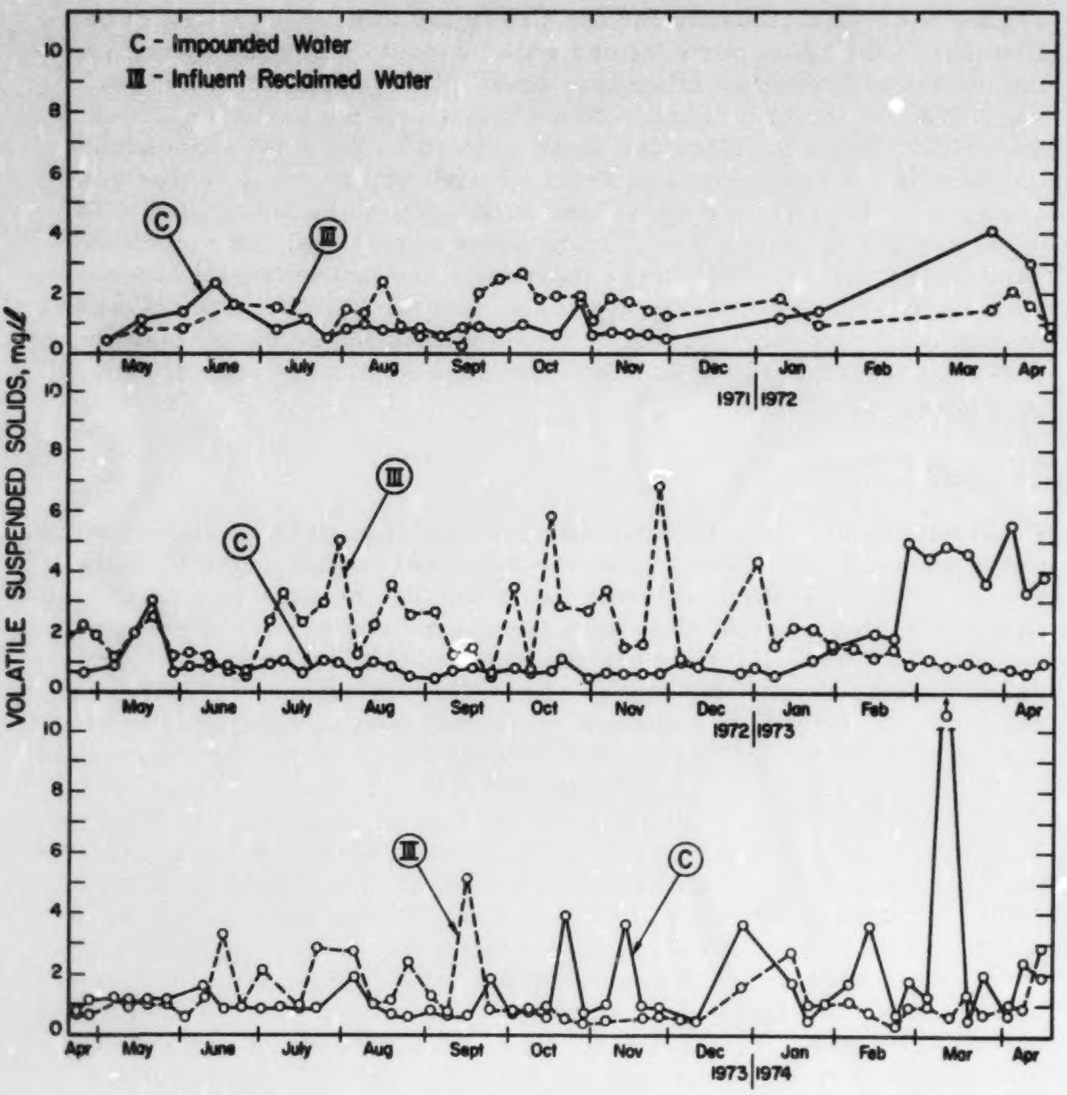


FIGURE 7. VSS, INDIAN CREEK RESERVOIR

substances (Figure 8). Reclaimed water is remaining relatively constant. Inasmuch as chloride is a conservative material in most biological and chemical systems, the observed difference in concentration of the reclaimed and impounded water is presumably due to a combination of surface runoff and evaporation after the initial leaching from underlying soil. It is difficult to estimate how much chloride may have leached from the disturbed soil during the initial reservoir filling operation. However, in the Tahoe basin the chloride concentration in precipitation and surface runoff from undisturbed land is less than 2 mg/ℓ [17]. Therefore, it appears that the chloride concentration of the impounded water is principally a function of that of the reclaimed water plus the concentrating effect of evaporation.

Note that the extremely low value observed in February 1973 probably represents a sampling error. Low concentrations of alkalinity and conductivity were also observed. Ice cover was still observed at ICR (Table 1) and it may be that the sample contained water from icemelt which would have lower concentrations of impurities than a completely mixed sample.

Conductivity

Values of conductivity observed during April 1971 through April 1974 are summarized in Figure 9. The same slight tendency for an increase with time previously noted in relation to chlorides is evident in the conductivity of both reclaimed and impounded water. However, a consistent drop in conductivity is apparent throughout the period of study as reclaimed water was mixed with the impounded water which included both surface runoff and effluent from the STPUD plant. Appendix 8 shows that the conductivity of impounded water ranged from 229 to 530 μ mhos/cm at 25°C. This is within the 0.25 to 0.75 m mhos/cm range reported by Eldridge [18] to characterize about half of the irrigation waters used in the western U.S. It is also in the range where the salinity effects are reported by the USDA [19] to be mostly negligible on field, vegetable, and forage crops.

It is therefore concluded that in terms of conductivity, water impounded in Indian Creek Reservoir is of good quality for its current use in irrigated agriculture.

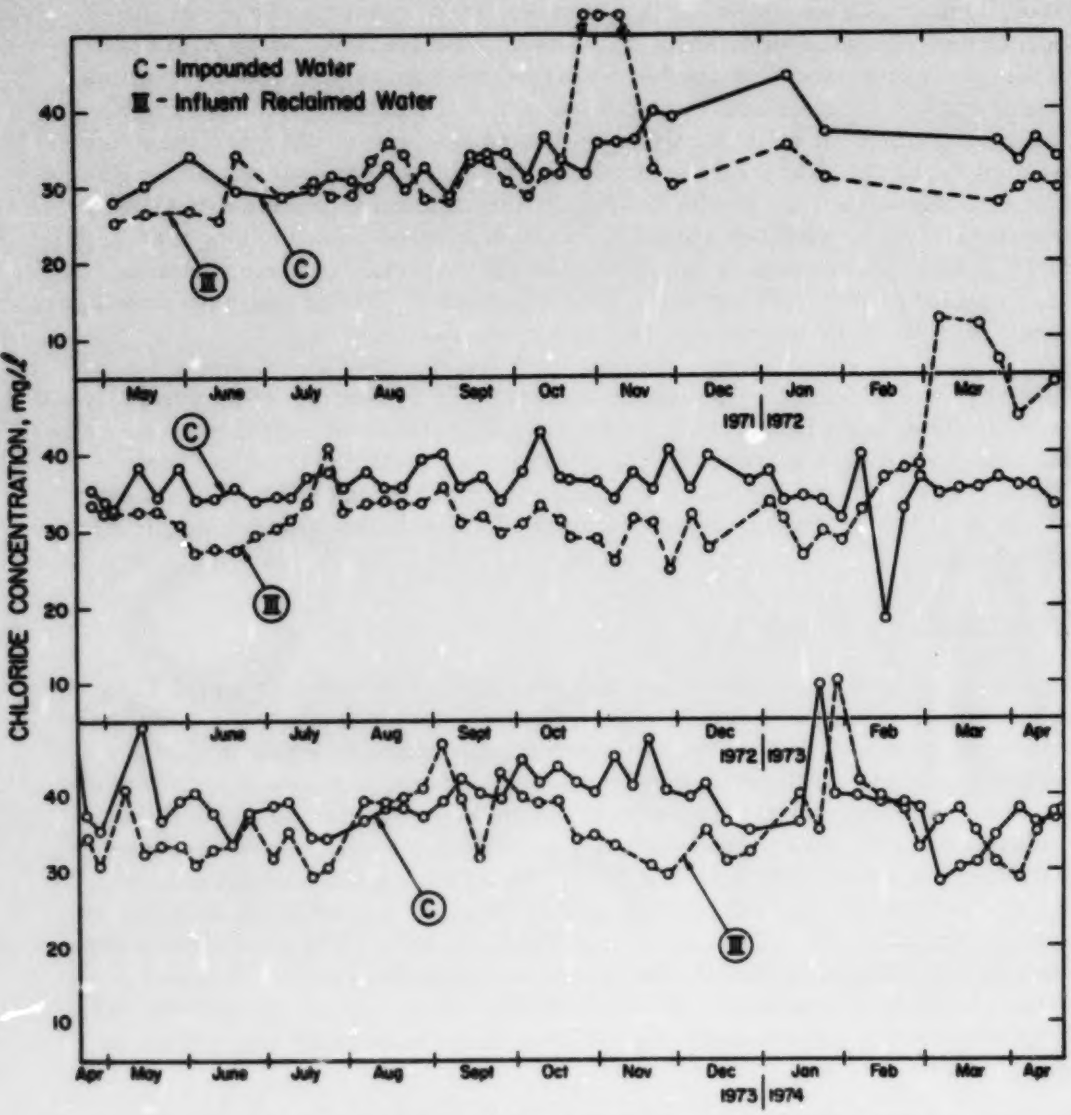


FIGURE 8. CHLORIDE, INDIAN CREEK RESERVOIR

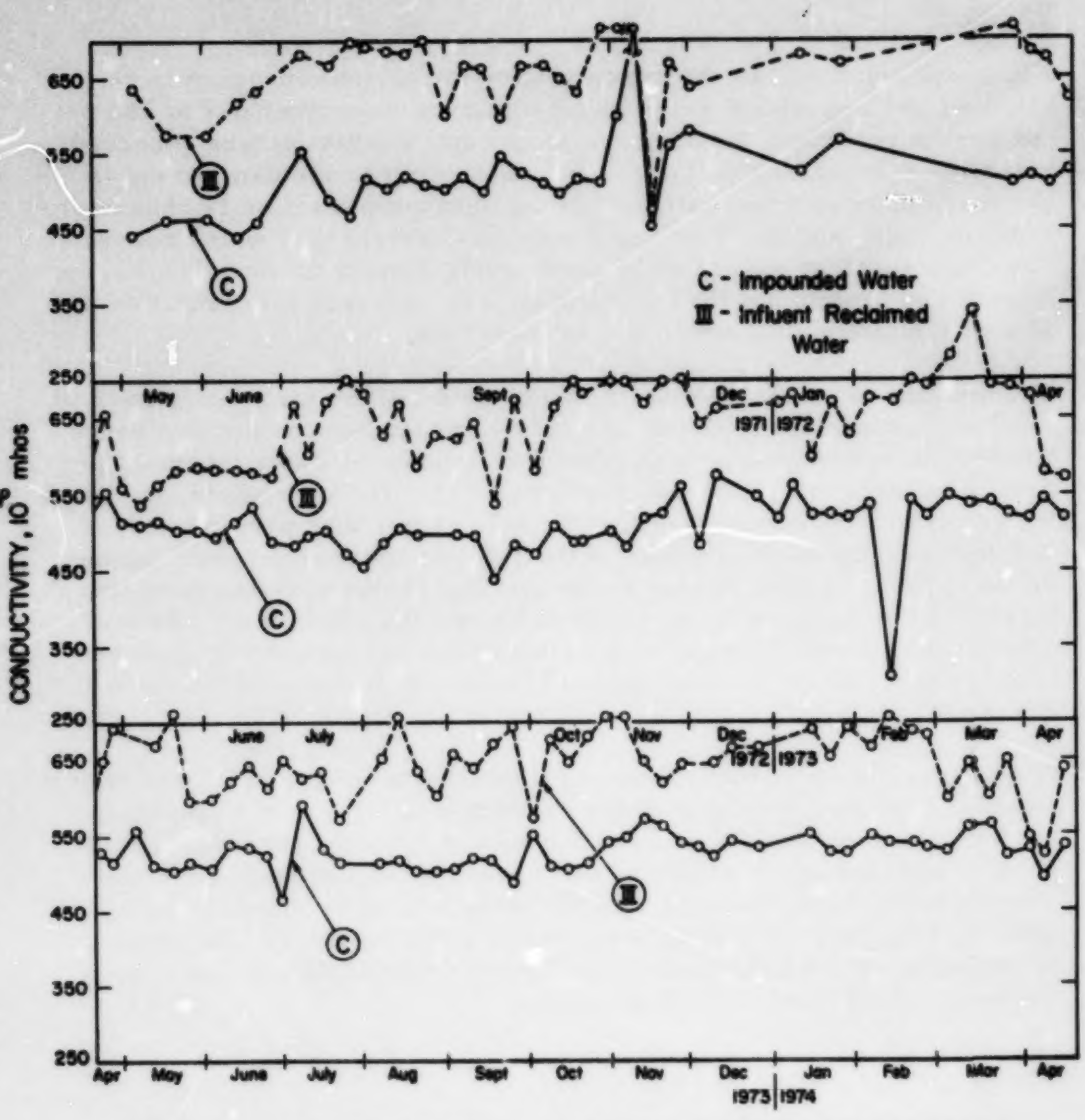


FIGURE 9. CONDUCTIVITY, INDIAN CREEK RESERVOIR

Calcium

Figure 10 summarizes the concentration of calcium observed in reclaimed and impounded water at Indian Creek Reservoir during the period herein reported. As in the case of other quality factors observed, transient fluctuations in the influent concentration are damped out in the mass of impounded water. The influent concentration is characteristically high, and the impounded water and discharged water curves are close together except when some unusual event occurred, i. e., in August and September 1969 when water was released for irrigation use at a rate of some four times the influent rate.

The question of whether dilution alone, or dilution plus precipitation of calcium carbonate or calcium phosphate, accounted for the difference in calcium concentration in influent and impounded water (about 71 percent of influent) was explored previously [4]. The conclusion, based on hydrologic calculations, was that dilution rather than precipitation of calcium was the major factor. This does not mean that precipitation of $CaCO_3$ and $Ca_x(PO_4)y$ was not occurring; it was possible to observe layers of $CaCO_3$ on exposed rocks and along the shoreline. However, dilution accounted for most of the change in calcium averaging 26 percent (over the April 1969 to April 1974 period) of the total inflow to ICR (Table 2).

$CaCO_3$ precipitation would depend primarily on temperature (solubility) and pH. The concentration of the carbonate species of the alkalinity system which essentially buffers the lake is very pH dependent. The pH was high enough to allow for measureable quantities of carbonates only during the summer (pH rise probably caused by photosynthesis); thus, precipitation of $CaCO_3$ was probably the reason for the slight lowering of calcium concentration observed during the summer, particularly in 1973 and 1974 (Figure 10).

pH

Variations in the pH of reclaimed and impounded water reported in Appendix 8 are shown graphically in Figure 11. In general, the two waters showed very little difference in pH. However, because pH is the negative logarithm of the hydrogen ion concentration it requires a tenfold concentration difference to change the pH by one unit. Therefore, the parameter is much less sensitive than other chemical parameters.

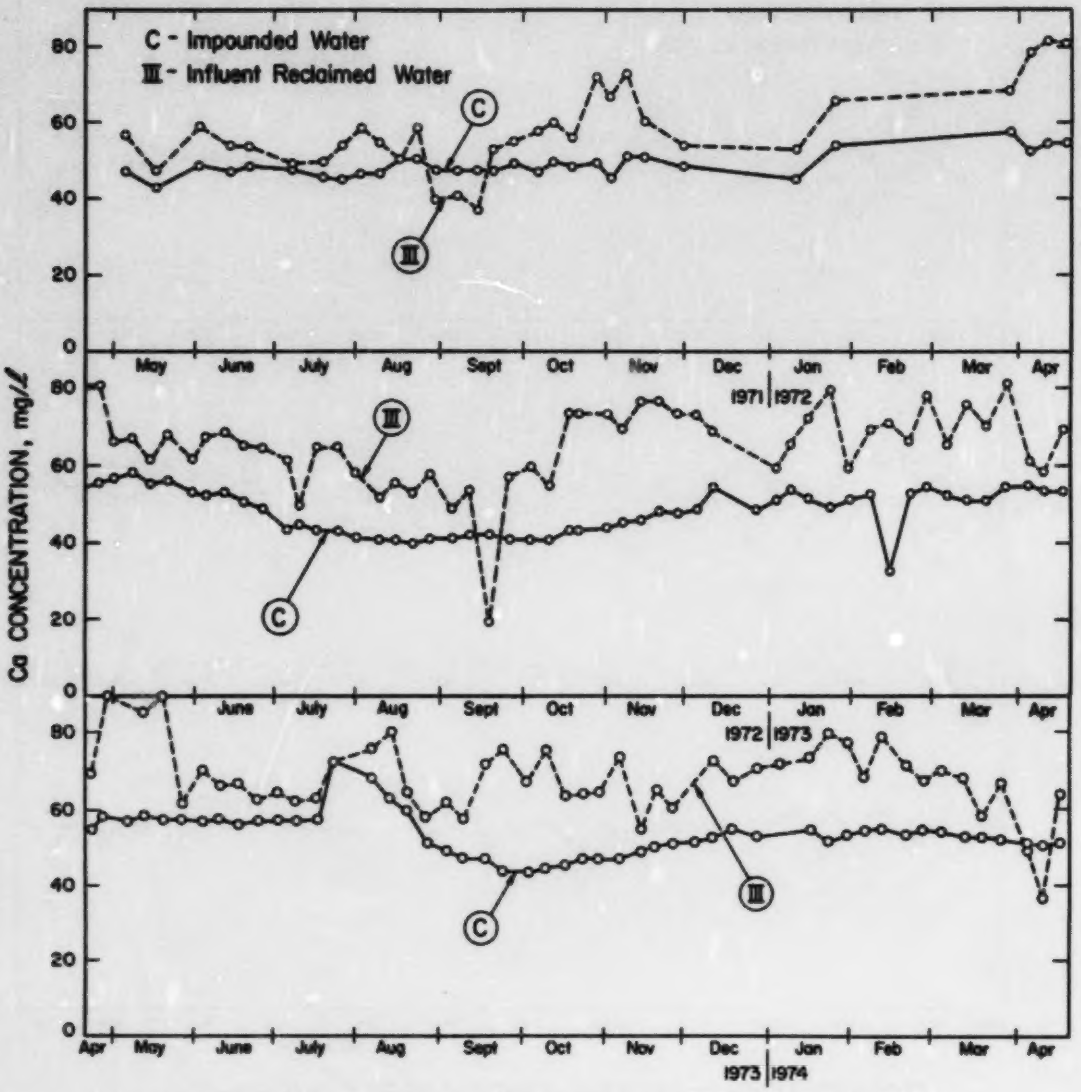


FIGURE 10. CALCIUM, INDIAN CREEK RESERVOIR

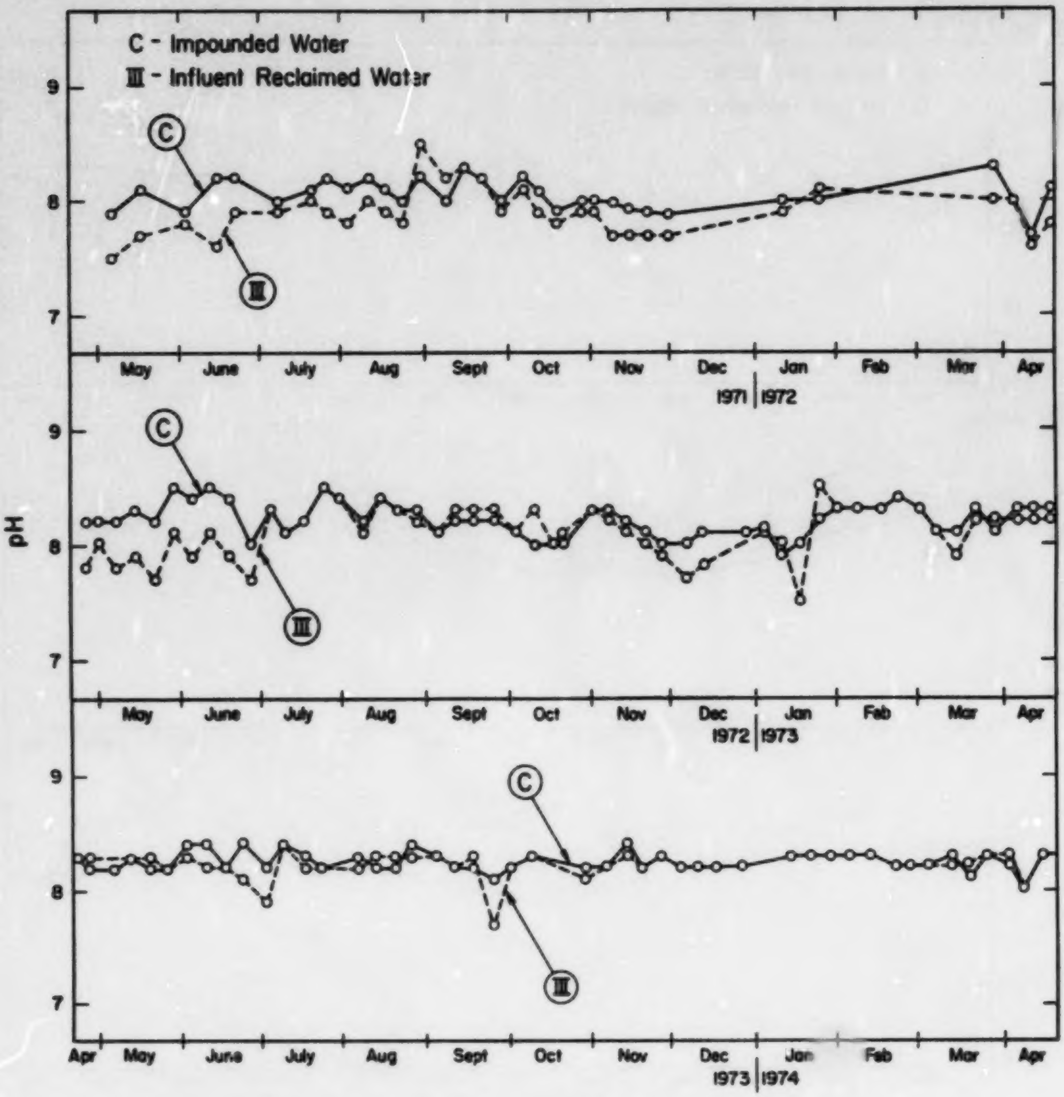


FIGURE 11. pH, INDIAN CREEK RESERVOIR

It is to be expected that during periods of extensive algal growth, free carbon dioxide will be utilized at such a rapid rate that the pH will show an increase. Such an increase is evident in Figure 11 during the February to April 1971 and 1972 period. Previous results [5] showed a more marked increase during that period. The pH seems to have stabilized around 8. 3 where all of the alkalinity is present as bicarbonate; thus little free CO_2 is present in ICR.

Alkalinity

Variation in the alkalinity of ICR waters is summarized in Figure 12. Variability of the influent reclaimed and impounded water is minimal. Although previous results indicated an upward trend in alkalinity with time over the period of study [5], the alkalinity seems to have reached a maximum level and stabilized.

That this was a function of treatment plant operations in precipitating phosphorus with lime and restabilizing the water, was shown in data on raw sewage at the STPUD plant. Here, for example, an increase in alkalinity from 192 mg/ℓ in the raw sewage to 221 mg/ℓ in the reclaimed water was reported for June 25, 1968; on January 18, 1969 this increase through the treatment plant was from 84 mg/ℓ in raw sewage to 208 mg/ℓ in the plant effluent [9].

As in the case of both chlorides and calcium, there is an appreciable difference between the influent alkalinity curve and that for the impounded water; impounded water alkalinity is about 60 percent of the influent water. Again, this brings up the question of the role of dilution in reducing concentration. As stated before about 26 percent of the reduction could be accounted for on the basis of dilution. A small fraction might be removed through precipitation (3 percent ?). The remaining quantity of alkalinity removed (about 10 percent of the influent) must be caused by the utilization of inorganic carbon during photosynthesis.

CHEMICAL OBSERVATIONS - PLANT NUTRIENTS

The quality of ICR is primarily a function of the concentration of plant nutrients (principally N, P, C, Fe) because other water quality parameters indicate good quality water. Little dilution (about 22 percent) of the plant nutrients in STPUD effluent occurs and since those waters are classified as eutrophic in terms of nutrient concentrations, the lake

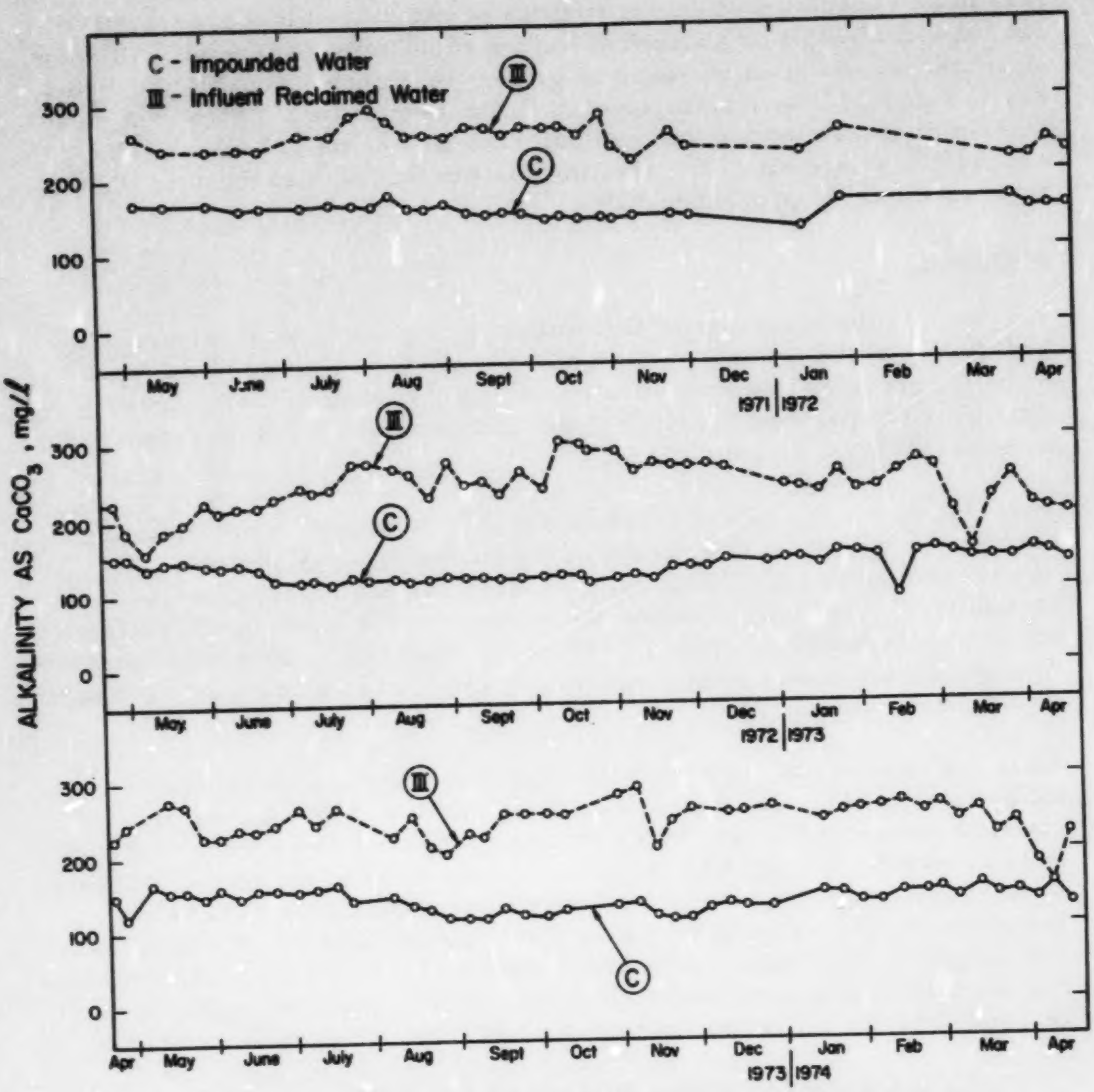


FIGURE 12. ALKALINITY, INDIAN CREEK RESERVOIR

waters are eutrophic and plant productivity of the lake is high. As will be shown in the section on biology of ICR, the algal productivity at least does not interfere with beneficial uses as much as would be expected because of the types of plant organisms present, an apparent consequence of succession.

The nutrient concentration in the reservoir is a function of the concentration in waters entering ICR and removal processes operating within the reservoir. The effect of the in-reservoir removal processes is reflected in the concentration differences between the III effluent waters pumped into the reservoir and the concentration actually in the reservoir (Table 3). Although long term trends are not discernible either in the reservoir or in the effluent from STPUD, higher in-reservoir concentrations of inorganic carbon and nitrogen and of orthophosphate are observed with higher STPUD effluent concentrations. The concentrations are considerably higher than are necessary to define eutrophic waters [20]. In the following paragraphs individual nutrients will be considered in more detail.

Inorganic Carbon

Figure 13 shows the inorganic carbon content of reclaimed and impounded waters. Inorganic carbon values were computed on the basis that inorganic carbon is present as the bicarbonate radical of alkalinity [21]. The computed values, therefore, are not only a function of alkalinity but also vary with the pH and temperature. As in the case of alkalinity the difference in concentration of inorganic carbon (Figure 13) between influent and impounded water cannot be attributed to dilution alone. The difference between the observed and the computed inorganic carbon in the impounded water leads to the inescapable conclusion that bicarbonate alkalinity was used as a source of carbon by the flora of Indian Creek Reservoir during the period of study.

Phosphorus

Because of its chemistry, phosphorus is the nutrient to which most removal processes are directed. At STPUD, carbonaceous BOD removal and phosphorus removal are extremely efficient (Appendix 9). The role of phosphorus in limiting algal blooms is well documented elsewhere. The most available form of phosphorus to algae is as orthophosphate; other forms may require dissolution, enzymatic conversion, or complex metabolic sequences to become available for algal growth.

Table 3. ANNUAL ARITHMETIC MEAN CONCENTRATIONS OF INORGANIC CARBON, INORGANIC NITROGEN, AND ORTHOPHOSPHATE IN ICR AND STPUD TERTIARY EFFLUENT

Parameter	Period - April Through March, Year	Arithmetic Mean Concentration, µg/l	
		In ICR(C)	In STPUD Effluent III
Inorganic Carbon	1970	29000	52000
	1971	35000	62000
	1972	38000	62000
	1973	32000	58000
	1974	33000	59000
Inorganic Nitrogen	1970	6300	19000
	1971	7200	20000
	1972	9600	23000
	1973	13000	26000
	1974	9700	22000
Orthophosphate P	1970	37	126
	1971	14	86
	1972	36	181
	1973	46	168
	1974	26	99

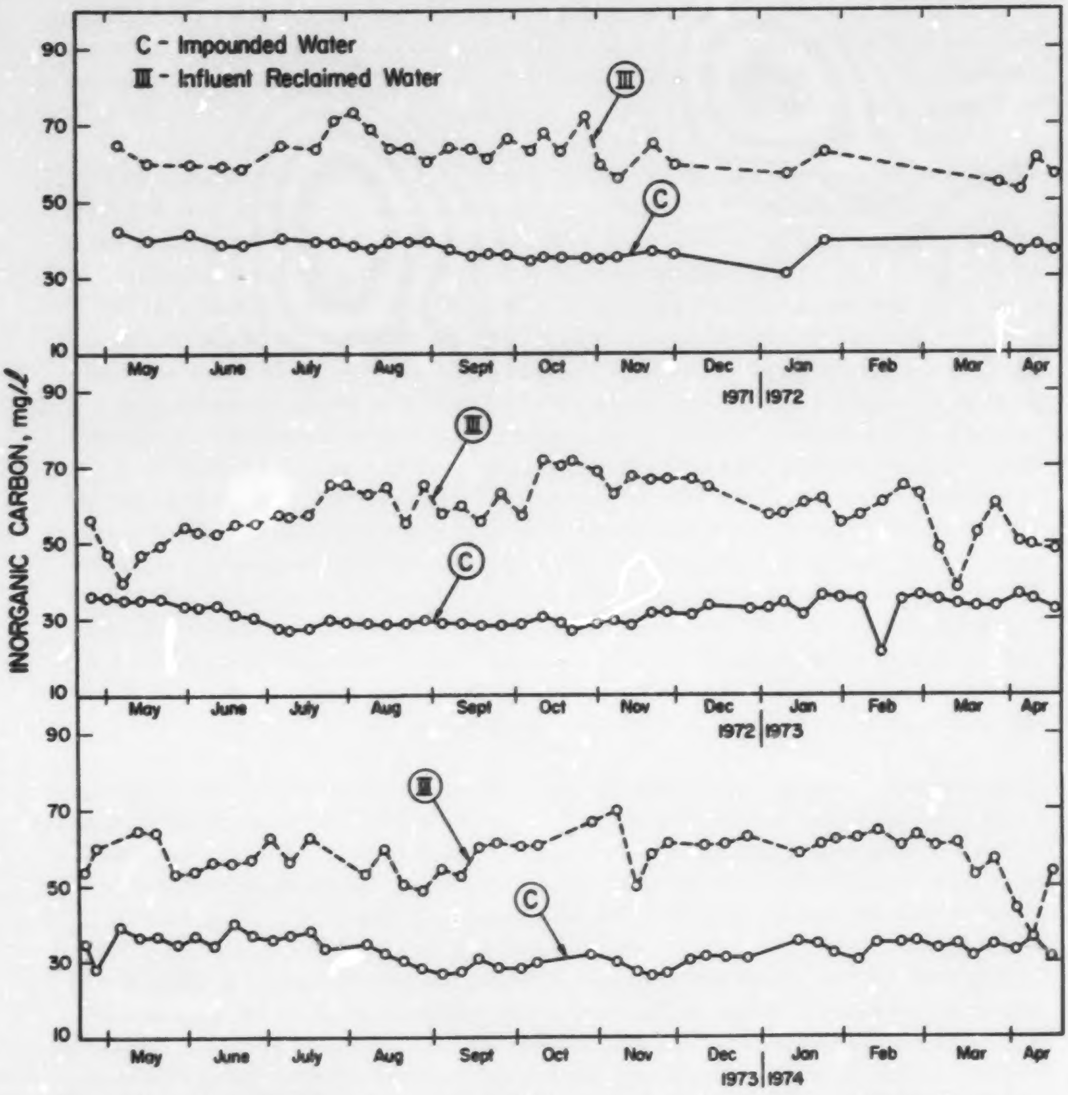


FIGURE 13. INORGANIC CARBON, INDIAN CREEK RESERVOIR

Consequently, most attention was directed toward orthophosphate as P (Figure 14). Also, total inorganic phosphorus [6] was analyzed (Total P in Figure 15). During the last year of the project, total phosphorus was measured by the persulfate technique and essentially no difference between the two methods was obtained. Thus little organic phosphorus was detected in the lake.

Phosphorus removal at the STPUD plant is a highly efficient process, which can reduce the concentration in the reclaimed water to a level which seldom exceeds 300 μg/ℓ. Removal is achieved by lime precipitation followed by recarbonation to precipitate the excess calcium carbonate. During the first period of study (April 1969 - March 1970) the total inorganic phosphorus content of the reclaimed water averaged 148 μg/ℓ and orthophosphate (PO_4-P) averaged 126 μg/ℓ; for the second period of study (April 1970 - March 1971) these same constituents averaged 119 and 86 μg/ℓ, respectively. Thus it appears, assuming that the raw sewage was of approximately of the same quality over the two study periods, that the efficiency of phosphorus removal improved at the STPUD plant as time progressed. However, in the third and fourth periods of study (April 1971 - March 1972), nutrient removal processes were altered to increase orthophosphate concentrations in the effluent in an attempt to chemically manage ICR to cause higher nitrification-denitrification and possibly weed control (Figures 14 and 15). This resulted in higher nutrient levels in ICR but did not achieve the desired effects on the aquatic ecosystem.

The difference in phosphorus concentration in reclaimed and impounded water is only partially accounted for by dilution. Phosphorus is a non-conservative material in that it enters into life cycles and essentially enters a sink in the benthic sludge or in living cells; hence it cannot be accurately traced by the dilution approach applied to conservative elements. From Figure 14 there appears to have been more orthophosphate in the impounded water during the winter than during the summer seasons, especially in the second period of study. This is explainable because winter temperatures and light conditions limit the ability of biota to increase and thus they cannot utilize the available phosphorus as completely.

It had previously been considered that orthophosphate concentrations in the reservoir would decrease with time as long as influent to ICR did not increase [5]. The relatively high concentrations of phosphorus in

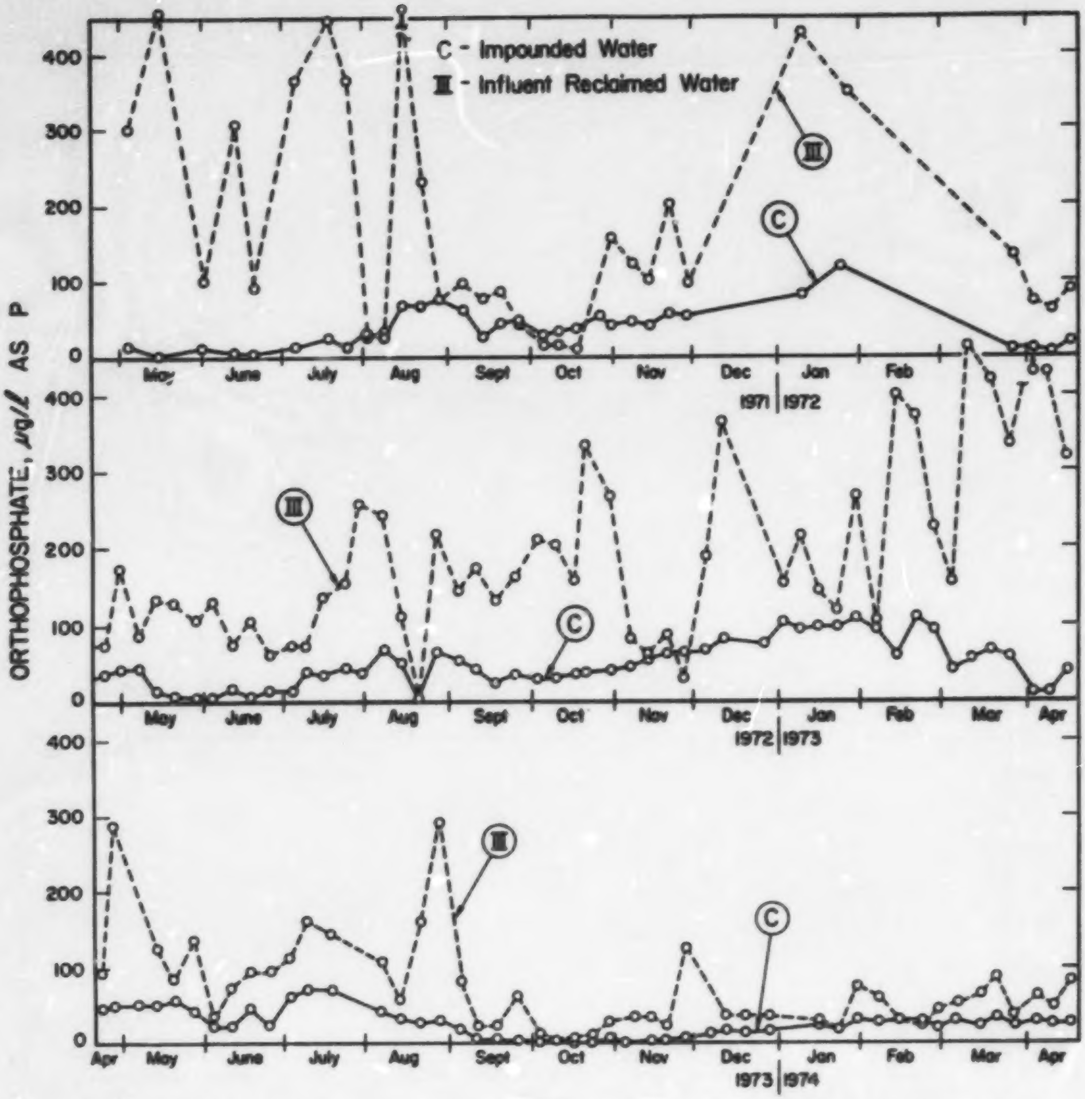


FIGURE 14. ORTHOPHOSPHATE, INDIAN CREEK RESERVOIR

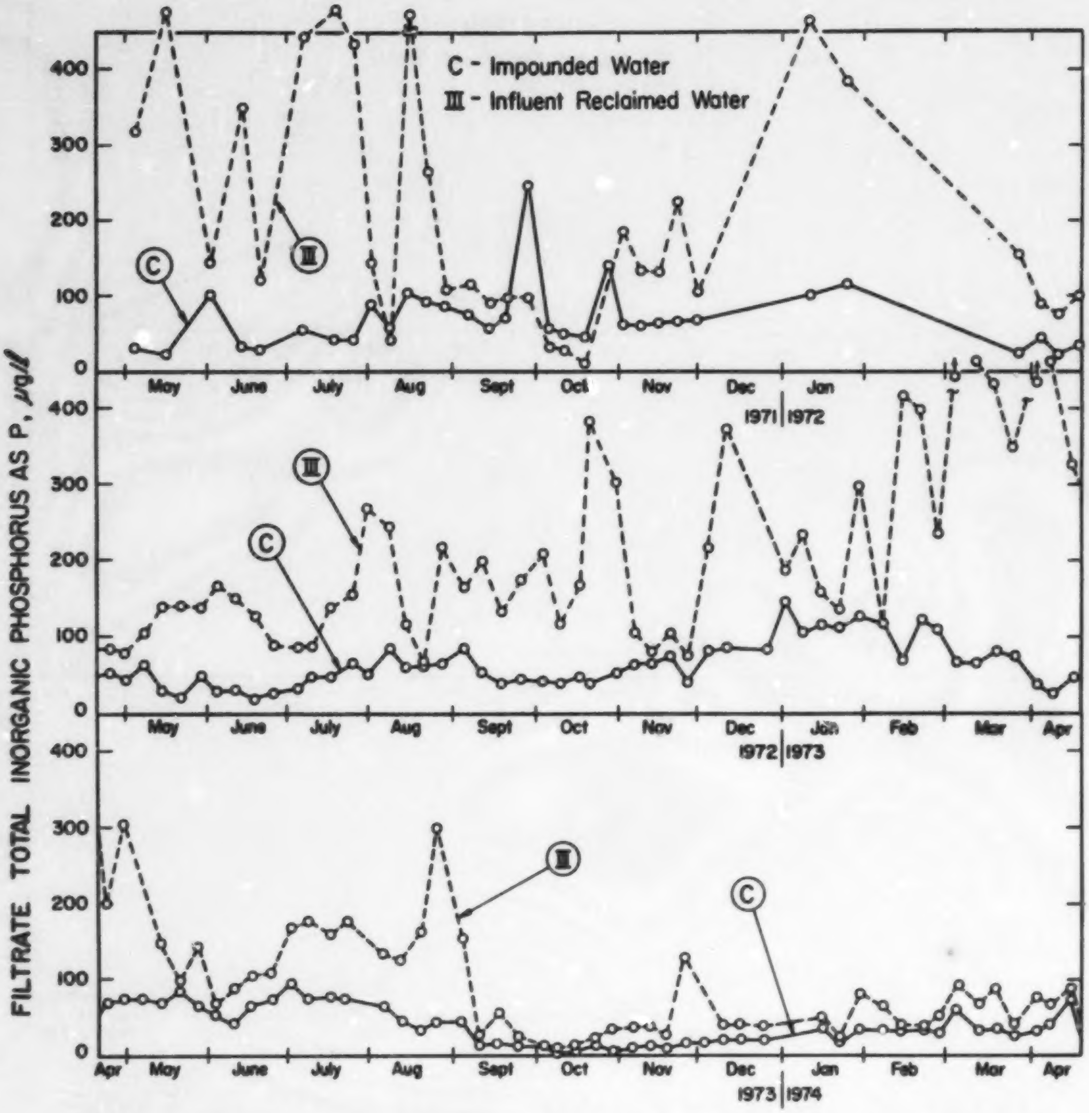


FIGURE 15. TOTAL PHOSPHORUS, INDIAN CREEK RESERVOIR

STPUD effluent (III) observed in the third and fourth years of study (April 1971 to April 1973) resulted in high concentrations of phosphorus in the reservoir during those years. An example of this effect can be seen from the minimum orthophosphate concentrations observed during those years and succeeding years. Minimum nutrient concentrations indicate the quantity of nutrient still in solution for uptake and utilization in further growth and as such gives an indication of the relative limiting factor. Because of "luxury uptake" zero minimum concentrations do not confirm nutrient limitation. The minimum concentrations typically were observed during May and June (Figure 14) when the phytoplankton bloom had essentially reached its maximum. During 1971, 1972, and most of 1973, 4 $\mu g/\ell$ of PO_4-P was the minimum concentration observed in ICR. However, as input of phosphorus was reduced in early 1973 a low of 1 $\mu g/\ell$ PO_4-P was observed during September, October, and November 1973 (Figure 14).

Ammonium

The inorganic forms of nitrogen (nitrate and ammonium) appear to be most available for algal and plant growth; however, ammonia has the additional environmental problem of being an oxygen sink and apparently being toxic to fish when significant concentrations exist and the pH is high enough (> 8.0) to result in toxic levels of free ammonia. Because most of the effluent nitrogen discharged from STPUD is in the ammonium form (Figure 16), it can cause problems in ICR in several ways: 1) oxygen utilization as nitrogenous BOD, 2) toxicity, and 3) nutrient for growth of plants. The ammonium ion is apparently nitrified to a great extent and plant growth and, more importantly, denitrification act as sinks for the nitrate formed by nitrification; nitrite is an important intermediate in nitrification but is not found in large quantities in ICR (less than 10 percent of nitrate).

The ammonium nitrogen concentration in the STPUD tertiary effluent averaged 18, 20, 22, 24, and 22 mg N/ℓ annually over the five years of study resulting in ICR concentrations of 3.4, 3.8, 5.3, 5.0, and 4.6 mg N/ℓ for the same years. A sharp increase in ammonium nitrogen concentration in summer 1972 (Figure 16), surprisingly did not affect the impounded water concentrations. The "biological buffering capacity" of ICR for ammonium ion can be thought of as a homeostatic device for the aquatic ecosystem.

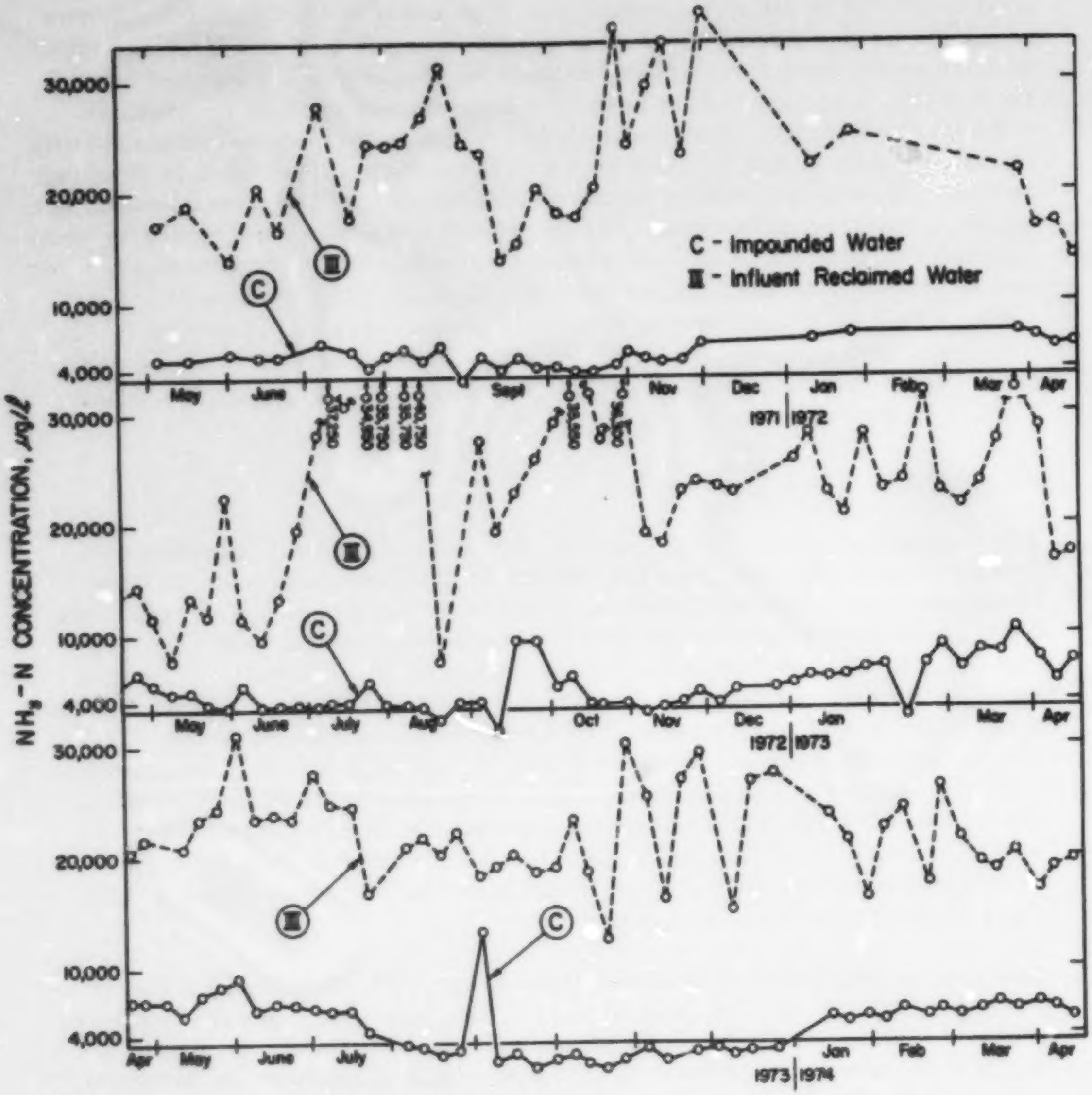


FIGURE 16. AMMONIA, INDIAN CREEK RESERVOIR

As in the case of most other water quality factors discussed in preceding paragraphs, the transient fluctuations in concentration characteristic of the influent water are damped out in the impounded water in the reservoir. From Figure 16 and the above comparison, it is obvious that only a minor fraction of the difference in ammonium concentration between influent and impounded water can be accounted for by dilution.

The mechanisms by which ammonium is so drastically reduced in Indian Creek Reservoir from influent to resident impounded water are perhaps the most important phenomena in the quality of ICR water. They represent the difference between a water definitely inimical to fish life and one in which fish have flourished for more than 2 years. They are discussed herein in greater detail in relation to the biological observations at Indian Creek Reservoir.

Nitrite Plus Nitrate Nitrogen

Appendix 8 shows that the values for nitrite nitrogen averaged less than 10 percent of those for nitrate nitrogen. Consequently, the two forms of nitrogen are combined for presentation in Figure 17. As was the case with ammonium nitrogen, biological activity more than overwhelmed the dilution effect; thus in the reservoir the influent nitrate-nitrite nitrogen was only a small fraction of that present in the reservoir. These vastly greater concentrations appearing in the impounded water are largely due to the oxidation of ammonium by biological activity in the reservoir. This may also be a pathway by which nitrogen is removed from the reservoir via nitrification-denitrification phenomena.

The typical situation of low concentrations of oxidized inorganic nitrogen and high concentrations of ammonium nitrogen in the effluent discharged by STPUD was not maintained during spring and early summer 1972. Just prior to the time that ammonium nitrogen increased to 35-40 mg N/ℓ, nitrate plus nitrite increased from a typical value of about 0.6 mg N/ℓ to as much as 14 mg N/ℓ. Although no measureable effect of increased influent concentrations on ICR concentrations of ammonium nitrogen was observed, the combined effect of the high inputs of total inorganic nitrogen was to result in an approximate doubling of total inorganic nitrogen in ICR over the whole year (4.4 increased up to 8.2 mg N/ℓ) and in a tripling to 12-14 mg N/ℓ during the period of high nitrogen input (April through November, 1972).

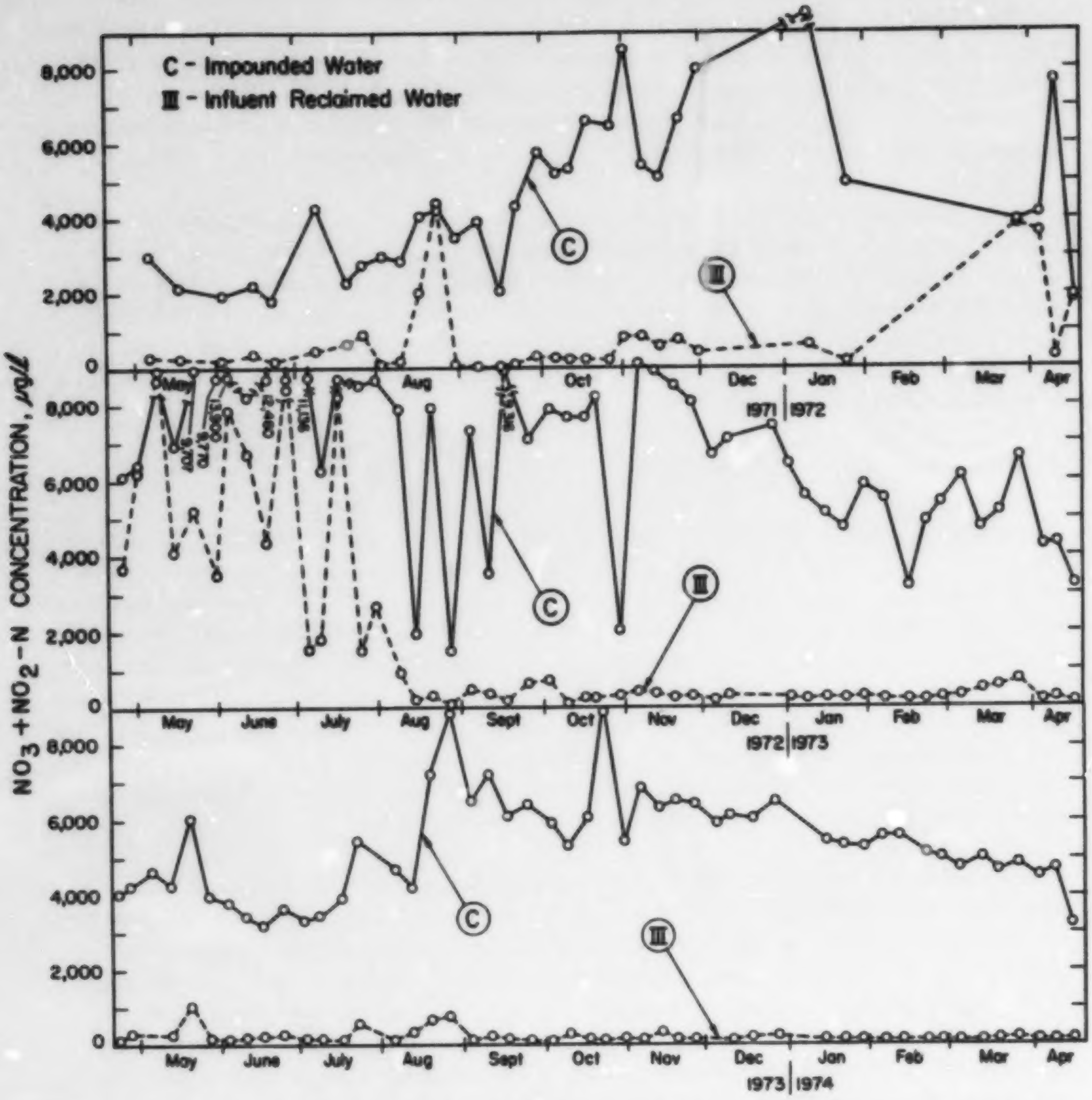


FIGURE 17. NITRATE & NITRITE, INDIAN CREEK RESERVOIR

Organic Nitrogen

Organic nitrogen is the only major quality factor herein discussed in which the concentration in the impounded water fluctuated as wildly as did that in the influent reclaimed water (Figure 18). Biological processes are used in the reclamation process. They are followed by precipitation, filtration, and carbon adsorption. Nevertheless, the reclaimed water is far from a uniform product in terms of organic nitrogen content. Higher organic nitrogen content was observed during the same period that higher inorganic nitrogen forms were discharged from STPUD. This coincided particularly with the period of nitrification at STPUD (May and June, 1972). At all other times the concentration of organic nitrogen was significantly higher than in the STPUD effluent. This may result from decay of the large amount of attached vegetation in the reservoir (see Biological Parameters of ICR, Section V) but no definitive correlations were made.

On the basis of Figure 18 it must be concluded that although there is nothing unexplainable in the behavior of the organic nitrogen curves, organic nitrogen is not a good parameter by which to describe the limnology of Indian Creek Reservoir.

Total Nitrogen

Table 4 shows that the total nitrogen in the influent reclaimed water is comprised mostly of ammonia, whereas in the impounded water the total is only about 50 percent ammonia. In both cases the average has increased slightly with time; a trend, which if continued over a period of years in parallel with a decreasing concentration of phosphorus, could have a profound influence on the biota of Indian Creek Reservoir. Beginning in 1972 and continuing halfway through 1973 a marked instability in concentrations of total nitrogen in ICR resulted from the higher inputs which were observed particularly in the summer of 1972 (Figure 19). When the high inputs of nitrogen were moderated, the concentrations in ICR apparently stabilized at 10-11 mg N/ℓ. It is obvious that nitrogen available for plant growth in ICR is more than adequate for bloom conditions.

Iron

In the first two years of study [5], the iron content of influent reclaimed water averaged higher than that of the impounded water. Because iron

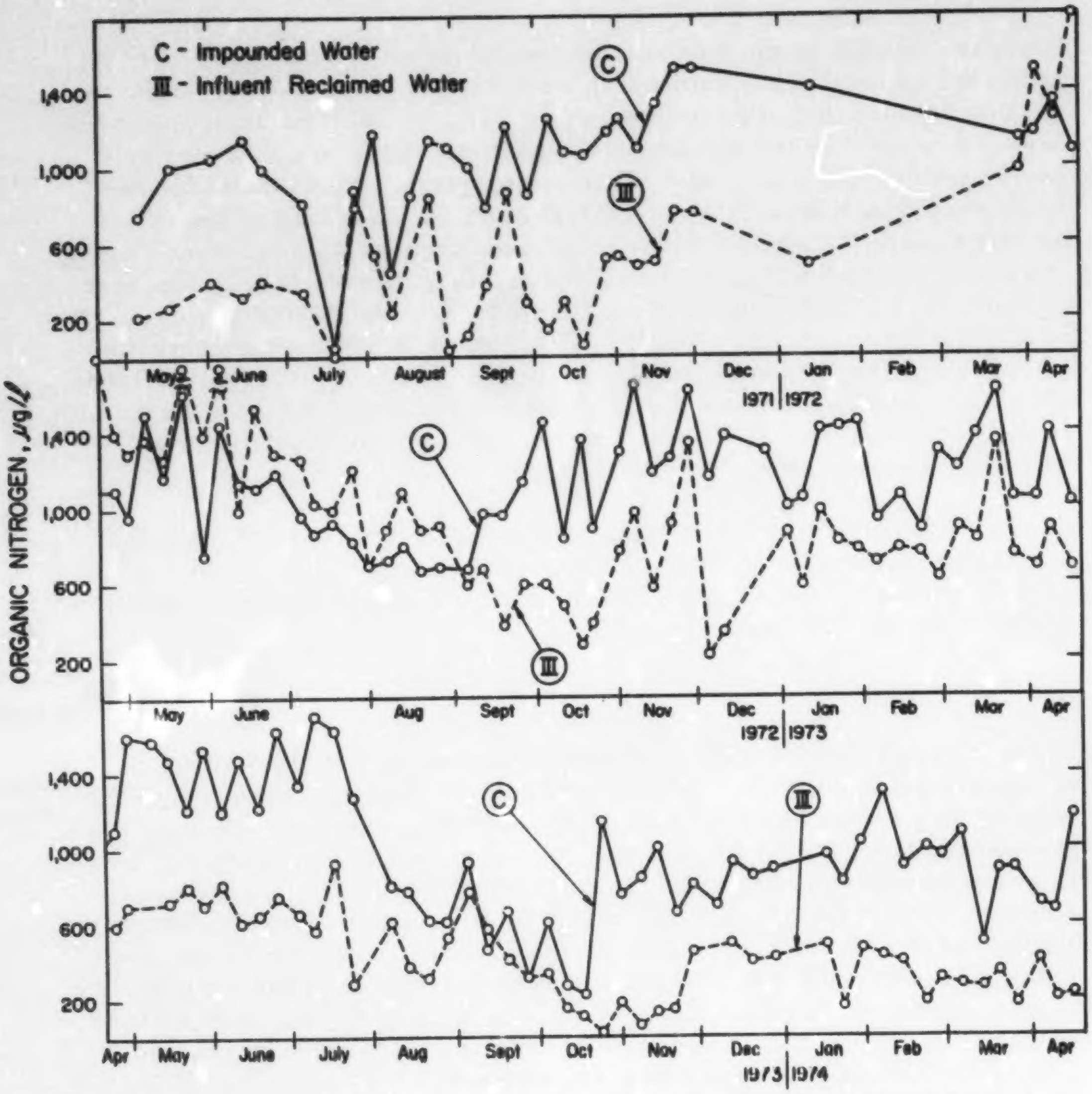


FIGURE 18. ORGANIC NITROGEN, INDIAN CREEK RESERVOIR

Table 4. ANNUAL ARITHMETIC MEAN CONCENTRATIONS OF NITROGEN AND PHOSPHORUS COMPOUNDS, INDIAN CREEK RESERVOIR

Sample	Period April Through March, Year	Mean Concentrations of Nitrogen Compounds, μg/l					
		NH_4-N	(NO_2+NO_3)-N	Total Inorg N	Total N	PO_4-P	Total -P
STPUD Effluent III	1970	17942	664	18606	19313	126	148
Indian Creek Reservoir (C)		3439	2893	6322	7241	37	51
STPUD Effluent III	1971	19588	295	19883	20395	86	119
Indian Creek Reservoir (C)		3810	3349	7159	8094	14	27
STPUD Effluent III	1972	22078	610	22688	23111	181	211
Indian Creek Reservoir (C)		5253	4353	9606	10640	36	69
STPUD Effluent III	1973	23624	2393	26017	26946	168	193
Indian Creek Reservoir (C)		5021	8209	13230	14377	46	63
STPUD Effluent III	1974	22040	188	22228	22684	99	114
Indian Creek Reservoir (C)		4608	5125	9733	10730	26	37

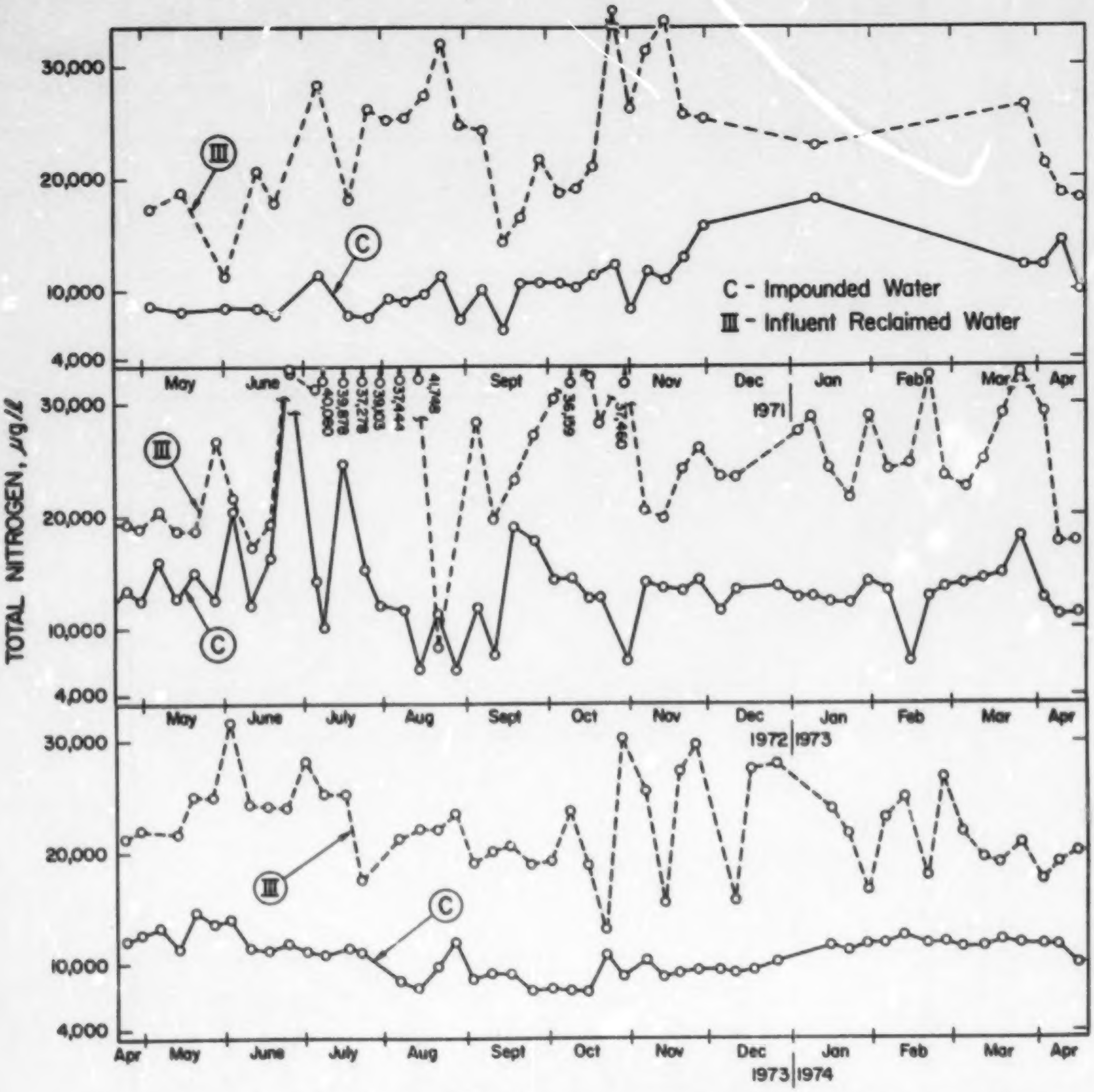


FIGURE 19. TOTAL NITROGEN, INDIAN CREEK RESERVOIR

was measured in filtered samples, such a condition could result from the taking up of influent iron by living cells or by precipitation of iron from the impounded water. The former would indicate that iron is an important factor in the production of biota in the reservoir, whereas the latter would be of little significance.

The concentration of iron in influent and impounded water was variable, particularly on a seasonal basis, being higher during the summer months when the visitor load on the Lake Tahoe Basin is greatest [5]. Analysis of raw sewage at the STPUD plant (Appendix 9) shows clearly that the STPUD effluent is much more concentrated in summer than in winter.

Previous results showed that from June to November 1969 there was a tendency for the impounded (C) and reservoir discharge water (B) curves to parallel each other, but little tendency to follow the pattern of influent iron (III) [5]. The greatest concentration of iron in the reservoir water was observed in June 1969 coincident with similar high concentrations in SS and VSS. Again in the spring and summer of 1970 the concentration of iron tended to follow the same pattern as that of suspended solids. This indicates that the presence of iron was related to the solids. However, because iron was measured in a filtered sample, the measured value could not have been incorporated in algal cells. The correlation may have resulted from turbulence and increased movement of iron from the bottom layers of the reservoir where solids are higher and dissolved iron (Fe^{++}) exists to the upper layers where the sample C is collected.

Figure 20 shows a closer correlation between STPUD effluent and impounded water than previously reported [5]. The iron in filtered water is apparently developing a pattern with low concentrations in the summer and higher concentrations in the fall and winter. The relationship between iron and biological productivity is unclear; the low concentration in STPUD effluent during June, July, and August appears responsible for the low levels in ICR at that time. Generally, the iron concentration in ICR appears to lag behind the previous measurement of iron in STPUD effluent; this temporal relationship indicates the present influence of STPUD effluent on iron levels in ICR.

In regard to other heavy metals, STPUD has had a sample analyzed at Battelle Laboratories (Appendix 10) and the results indicate that none of the metals were at toxic levels. The iron concentration listed is about 2 orders of magnitude less than typical values measured by

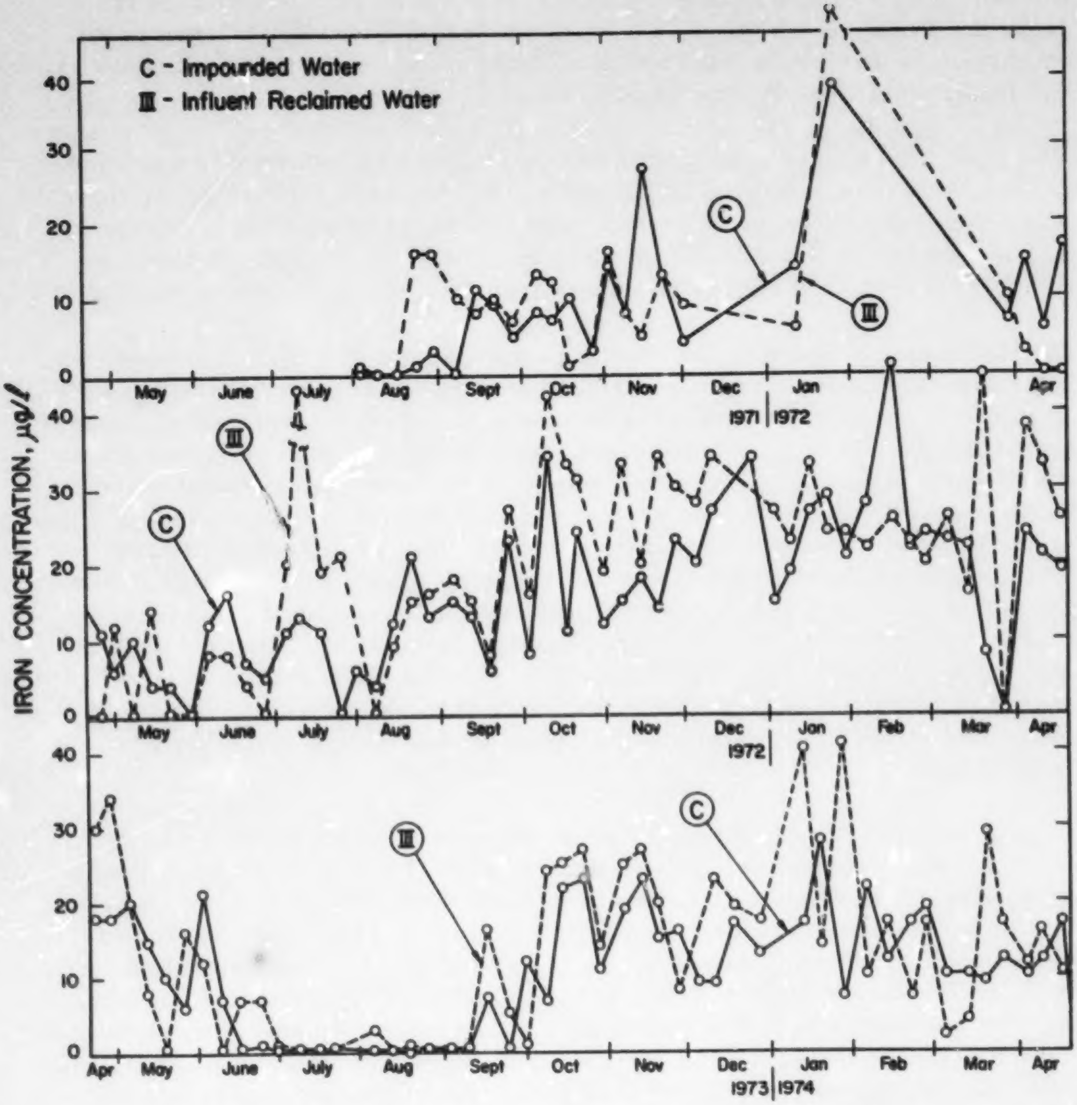


FIGURE 20. IRON, INDIAN CREEK RESERVOIR

project staff for both STPUD effluent and ICR samples (typically 10-15 μg Fe/ℓ, filtered samples). This discrepancy may represent a difference in samples or be caused by differences in analytical technique. Staff analyses seem reasonable in light of results presented by other laboratories on similar waters. Note: iron will not be studied in the following nutrient inventory because of such data uncertainties.

Inventory of Nitrogen and Phosphorus in ICR

An inventory of nutrients is presented in Table 5 for the two periods of study herein reported. Hydrologic data were previously summarized in Table 2. Loss by evaporation was omitted becasue the amount of chemicals transported by evaporation is insignificant in comparison with the amounts present in the reclaimed or impounded water. The arithmetic signs shown in the Δn columns of Table 5 pertain to the inventory equation expressed in the form: $\Delta n = I + RO + P_L - D - P_o - V_o - \Delta S$, in which Δn is the difference in the factor inventoried. A positive value of Δn indicates that more material went into the reservoir than is accounted for by the combination of observations, estimates, and assumptions available for evaluating its fate when making the inventory (Table 5). Other symbols used in the equation are as defined in relation to Table 2 but refer to mass flows in this context. By multiplying the respective concentration by the appropriate water flow in the inventory equation to obtain mass flows, Δn is expressed in terms of the nutrients, nitrogen and phosphorus. Influent values (I) are concentrations of N and P in STPUD effluent; rainfall (P_L) and runoff (RO) values are from a previous report [5] assumed to apply to all 5 years; all subtractive values are from concentrations measured in the reservoir. Only annual flow (Table 2) and total nutrient (Table 4) values are used. Several other assumptions were assumed to hold:

1. Only oxidized forms of nitrogen (NO_3, NO_2) were assumed to leave the reservoir via percolation; ammonium and organic nitrogen were assumed held in the sediments.

2. No phosphorus was assumed to leave the reservoir via percolation but was assumed to be retained in the sediments.

Thus of the calculated output 41.4 metric tons of nitrogen and 0.47 metric tons of phosphorus entered the sediment phase via percolation. Probably they would remain there until chemical conditions in the overlying water were to change enough to allow their release to the overlying waters.

Table 5. ANNUAL NUTRIENT INVENTORY ESTIMATION FOR INDIAN CREEK RESERVOIR

Year of Study Ending	Annual Values, metric tons (1000 kg)					
	Nitrogen			Phosphorus		
	Input	Output	Δn (%)[a]	Input	Output	Δn (%)[a]
March 1970	64.0	33.8	30.2 (47)	.527	.238	0.289 (55)
March 1971	67.9	32.7	35.2 (52)	.422	.110	0.312 (74)
March 1972	86.3	49.9	36.4 (42)	.810	.326	0.485 (60)
March 1973	106.1	67.7	38.4 (36)	.783	.296	0.487 (62)
March 1974	101.2	56.7	44.5 (44)	.533	.195	0.338 (63)

[a] Percent values refer to nutrients which are unaccounted for each year by simple hydrological relationships and hence reflect nutrient utilization in chemical-biological systems.

As is obvious in Table 5 considerably more nitrogen is lost from the system than can be accounted for by biological and sediment sinks. Using previous results of the first two study periods, it was estimated using more detailed results that phosphorus loss in ICR was into biological and sediment (primarily) sinks [5]. An estimate of concomitant nitrogen loss explained a small fraction of the unaccounted nitrogen. The remaining unaccounted nitrogen was ascribed to nitrification-denitrification using rate measurements of those functions and mass balance estimates to lend support to that explanation [5, also see 22]. The relative constancy of the unaccounted for nitrogen and the system at ICR suggests that similar patterns of the fates of nitrogen and phosphorus are still ongoing at present and that nitrification-denitrification is the important sink for nitrogen.

The decreasing percentage of unaccounted for nitrogen indicates that the capacity of ICR to denitrify is fixed by some environmental factor (too much oxygen or organic energy source?) and that modification of some parameter related to the factor might lead to a lowering of nitrogen content of the water and reverse the apparent trend to higher nitrogen content in the reservoir. However, the consequences of such a modification might lead to higher ammonia content and thus a greater opportunity for ammonia toxicity to the fish.

CHEMICAL OBSERVATIONS - DISSOLVED OXYGEN

Dissolved oxygen is one of the more indicative and affected parameters of biological interactions in aquatic systems and this is well illustrated at ICR. Dissolved oxygen data for Indian Creek Reservoir waters throughout the period of study are presented in Appendix 8. Variation in DO with depth below the water surface has been shown for periodic sampling dates during the 1969-70 study period and at approximately weekly intervals since then. From Appendix 8 it may be observed that the dissolved oxygen content of the influent reclaimed water was generally less than or equal to 2 mg/ℓ except on a few occasions which may well be in error due to problems of sampling from a pressure outfall line without aerating the sample.

Figure 21 shows that throughout nearly the entire period of observation the impounded water in the top half-meter was near or above saturation (calculated from table in [6] at 576 mm pressure), varying normally with water temperature. Those samples which apparently exhibit undersaturation may represent sampling error or bias in calculation but even if those values are correct, the conclusion would be that generally ICR remains well oxygenated. The low values seen in spring and early

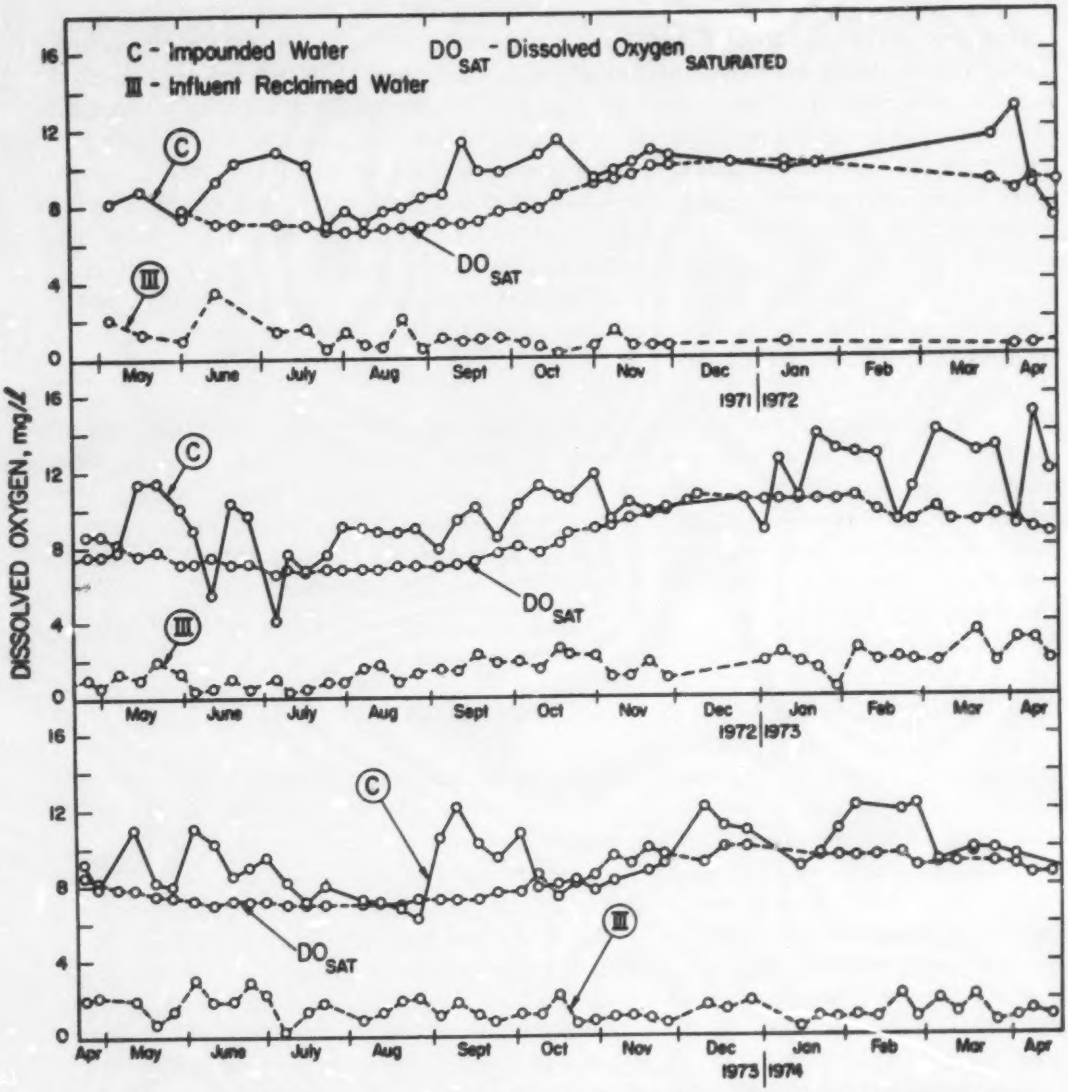


FIGURE 21. DISSOLVED OXYGEN, INDIAN CREEK RESERVOIR

summer 1972 apparently resulted from the high ammonium nitrogen loadings which occurred then.

Supersaturation probably resulted from photosynthesis and generally occurred during three periods of time: winter, early summer, and fall. The winter period of supersaturation has become more marked with time, occurring earlier each year. This coincided with the phytoplankton bloom described in Table 1 and the loss of clarity as interpreted from decreasing Secchi disc readings. The early summer period of supersaturation coincided with increased aquatic vascular plant growth and expansion of these weeds into deeper water along with increased water clarity. The fall period of supersaturation again was caused by the weeds as maximum clarity was observed at this time. Apparently suspended sediments interfered with light transmission during July and August because clarity decreased (Table 1) and suspended sediments increased (Figure 6) at that time.

Generally the reservoir showed a well mixed condition in terms of dissolved oxygen during the spring and fall. In the summer and winter slight gradients occurred which the artificial aeration of ICR could not completely overcome. Low benthic concentrations commonly were observed during early summer until conditions had improved to allow near vertical saturation: 0.7 mg/ℓ on 6/21-71; 2.5 mg/ℓ on 6/5-72; 6.2 mg/ℓ on 8/2-73.

The maturation of ICR is reflected in the development of more complete distribution of dissolved oxygen within the reservoir. Previously, long periods of benthic anaerobiosis existed [5]. For example, in July 1969 the dissolved oxygen in the vertical profile of the reservoir ranged from 7.6 mg/ℓ at 0.5 meters below the water surface to 0 mg/ℓ at 0.5 meters above the reservoir bottom. By September 1969, however, the dissolved oxygen profile at all three of the sampling stations (Figure 2 [5]) revealed a well mixed water mass both vertically and horizontally, with a reduction in concentration of oxygen in the upper strata as a result of mixing with underlying oxygen-poor water.

Part of this improvement may have been due to the long term effects of artificial aeration. In March of 1970 mechanical aeration was initiated but was interrupted after only about 10 days of operation until June 23. In the interval, in May 1970, an oxygen profile began to develop. By early June it showed a DO range of from 11.1 mg/ℓ at -0.5 meters to 1.4 mg/ℓ at -10 meters. However, a well mixed condition developed by June 16, before the artificial aeration system was restored. Thereafter, as the weather warmed up and aeration was practiced, oxygen profiles were less pronounced until mid-July when the steep oxygen profile of the preceding July was essentially repeated, albeit with a low of 1.5 mg/ℓ instead of 0 mg/ℓ as before. A second period of low oxygen in the bottom stratum occurred in August. Then from September 1970 to the end of the report period in May 1971 the DO in impounded water was at or above saturation throughout the vertical profile.

From the data observed, the exact effect of artificial aeration of Indian Creek Reservoir is obscure. Both before and after installation of the system, periods of complete mixing and strong stratification occurred. In general it appears that the oxygen depletion at the bottom of the reservoir was less severe and DO concentrations under well mixed conditions were somewhat higher after operation of the aerator began. Problems in aerator operation and general improvement in the reservoir oxygen regime (aquatic plant photosynthesis, etc.) as well as maturation of the system have made it difficult to interpret exactly the role of aeration.

An interesting observation was the typical fall reversal of dissolved oxygen so that the highest concentration was observed at the bottom of the reservoir. The pattern is illustrated in Figure 22 for those dates where the phenomenon is most obvious. The events leading to the development of the plant growth responsible for this observation are discussed in the section on Biology of ICR.

CHEMICAL OBSERVATIONS - SEDIMENT ANALYSES

Sediments consist of materials deposited on the original substratum of the reservoir and as such represent minerals, sorbed materials on silts and clays, chemical precipitates, organic detritus, and living plants and animals. Sediment concentrations of organic carbon (C), total nitrogen (N), and total (P) and available phosphorus (AP) indicate the probable sources of lake sediments. If the ratios of C/P and N/P are less than typical values for organisms (e.g., $C_{40}N_7P_1$ on a weight basis calculated from [23]), one would expect a greater effect from chemical removal (sorption and precipitation) than from biological mechanisms or a change in yield relationships due to changes in limiting factors. Because such yield ratios are only indicative of actual relationships, only speculations can be made and hypotheses derived for later studies.

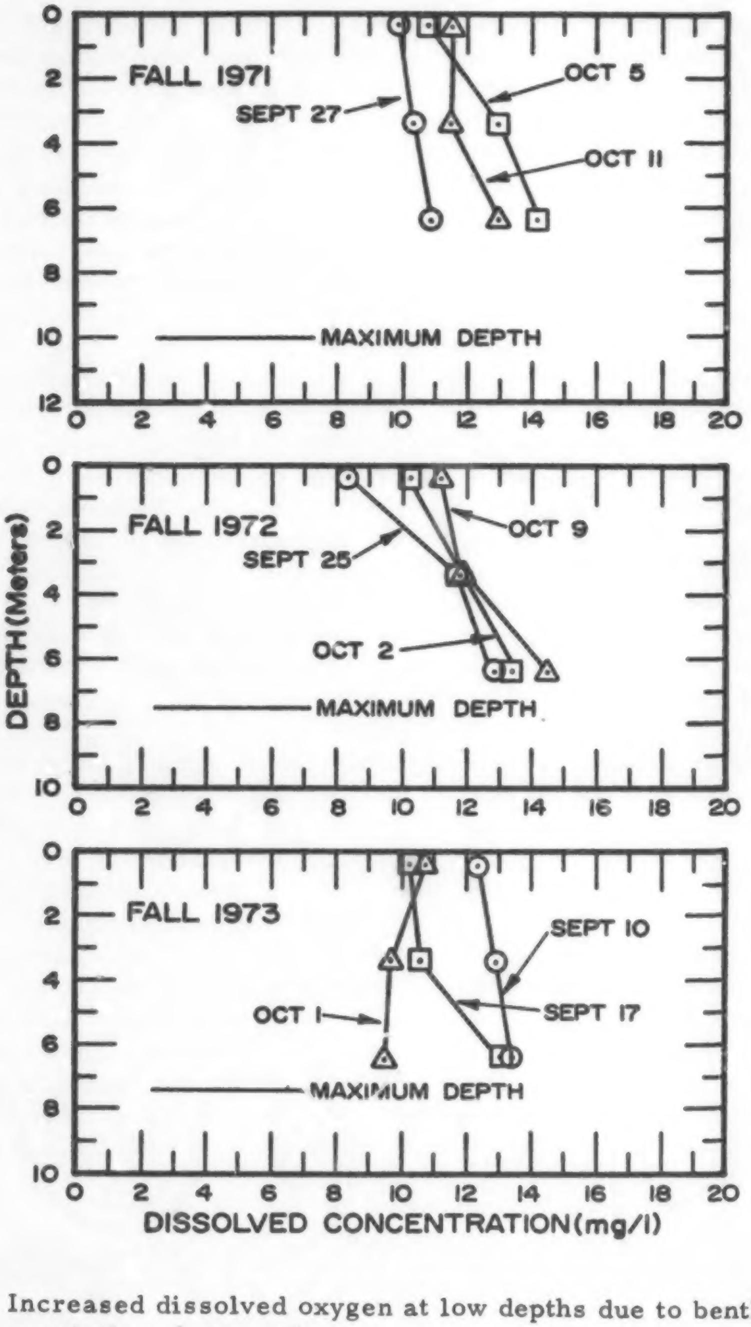


Figure 22. Increased dissolved oxygen at low depths due to benthic vegetation photosynthesis.

Analyses of Ekman dredge samples collected on October 20, 1972 from Indian Creek Reservoir show distinct changes with either distance from the source of tertiary effluent to the reservoir (Station 1) or with depth since these two factors are not separable (Table 6). One would expect higher concentrations of nutrients with depth because easily resuspended material such as organic detritus would tend to accumulate in the deepest part of the lake. Although lower diversity in benthic samples from ICR, collected closer to the source of tertiary effluent, has been observed [22], greater benthic biomass (numbers) occurred in the deeper portions.

The higher P concentrations in relation to N and C indicate chemical removal mechanisms or that P was not limiting the microbial populations. Because the C/N ratio for the samples was high (10-13 as compared to 5.7 for Stumm and Leckie [23]) and the AP, a measure of inorganic phosphorus (see [10]), was low, it appears that some other factor yet unexplained affected the nutrient relationships.

The shoreline sample showed the highest P and N concentration and the second highest C concentration reflecting the high addition of organic matter as considerable aquatic vascular plant growth had taken place in the sampling area.

Essentially similar results were obtained for analyses performed on samples obtained on August 6, 1973 (Table 6). Because the shoreline sample was highest in October a core sample, collected by diver (Tom Walsh), was collected and analyzed. This showed a pattern which would be expected along the shoreline; the aquatic vegetation dies, decays and collects in the shallow area producing relatively high C/N and C/P ratios in the upper sediment layers. A calculated completely mixed core on a weighted depth basis would have about 20 mg organic C/g sediment, 1.6 g N/g, and 0.36 g P/g or a weight ratio of $C_{55}N_4P$. The low phosphorus content in the shallow waters of the east shore produces a different ratio than obtained in the October sample from the west shore. Note that soil in the ICR basin (described in [5]) showed a similar composition to the lower strata of the core sample having 11 mg organic C/g and 0.6 mg N/g of soil.

Table 6. CONCENTRATIONS OF NUTRIENT ELEMENTS IN SEDIMENTS OF INDIAN CREEK RESERVOIR

(Nutrients,[b] mg/g dry weight (103°C)

Station[a]	Total Available Phosphorus	Total Phosphorus	Organic Carbon	Total Nitrogen	Element Weight Ratios, $C_xN_yP_1$
October 20, 1972					
1	0.042	0.66	23	1.8	$C_{35}N_3P$
2	0.030	0.62	18	1.5	$C_{29}N_2P$
3	0.028	0.50	14	1.3	$C_{28}N_3P$
4	0.029	0.70	18	1.8	$C_{26}N_3P$
5	0.037	0.75	14	1.3	$C_{19}N_2P$
Shoreline West of 5	0.039	1.20	22	2.0	$C_{18}N_2P$
Samples Collected on August 6, 1973					
1	-	0.80	30	3.7	$C_{38}N_5P$
2	-	0.38	13	1.0	$C_{33}N_3P$
3 South Trans	-	0.71	20	1.7	$C_{27}N_2P$
North Transect Samples					
1000 foot	-	0.74	22	1.8	$C_{30}N_2P$
1200 foot	-	0.77	7	0.6	$C_{10}N_8P$
Core Sample Collected near Shore East of Station 3 August 6, 1973					
Core Depth, cm					
0 - 1	-	0.86	64	7.2	$C_{75}N_8P$
1 - 2	-	0.67	43	3.5	$C_{64}N_5P$
2 - 3	-	0.40	21	1.4	$C_{53}N_4P$
3 - 5	-	0.34	29	1.8	$C_{87}N_5P$
5 - 7	-	0.28	23	1.6	$C_{82}N_6P$
7 - 12	-	0.27	9.0	0.7	$C_{33}N_2P$
12 - ~15	-	0.27	4.5	0.5	$C_{17}N_2P$

[a] See Figure 2.

[b] Analyses performed according to procedures in [24].

BIOLOGICAL OBSERVATIONS

Introduction

Because many of the nutrients are affected by the aquatic food chain in the ways in which they are distributed and transferred throughout the various phases of the aquatic ecosystem, it is necessary to obtain some measurements of the different members of the food chain and attempt to relate them to various distributions of nutrients in the reservoir. To simplify relationships, different species in the reservoir community are grouped into particular functional groups which relate to energy and nutrient transfer and utilization. Heterotrophic microorganisms would include all organisms which utilize organic carbon compounds as a source of energy while autotrophic organisms utilize sunlight as a source of energy and furthermore are the ultimate basis for the growth of the heterotrophic group. Primary consumers include those organisms which prey on the producing organisms; because primary consumers are usually filter feeders (zooplankton) or other herbivores (e.g., snails) their food at ICR is made up of particulate matter (debris, heterotrophic and autotrophic microorganisms) and vascular plants, respectively. Higher consumers would include the trout planted at ICR which feed on insects, zooplankton, and snails. A simplified schematic of the food web at ICR and its relationships to nutrient flow is shown in Figure 23. The measurements of the different levels in this system (Figure 23) will be made in the following paragraphs.

Microorganisms

Bacteria, algae, and protozoans are included in any discussion of microorganisms. These groups occur in both planktonic and attached forms. The attached forms include "slimes" as well as filamentous growths. Filamentous attached algae will be discussed in the paragraphs on Benthic Vegetation.

Plankton counts of algae and protozoa are based on samples collected with a modified "Hale's Sampling Bottle" [25] which collects an integrated sample throughout the depth sampled. A 500 ml sample could be collected from a 10 meter depth of water by steadily pulling the bottle through the water for about 90 seconds. Plankton counts were made with a Sedgewick-Rafter cell and a calibrated Whipple eyepiece. These estimates are necessarily relatively crude both in terms of

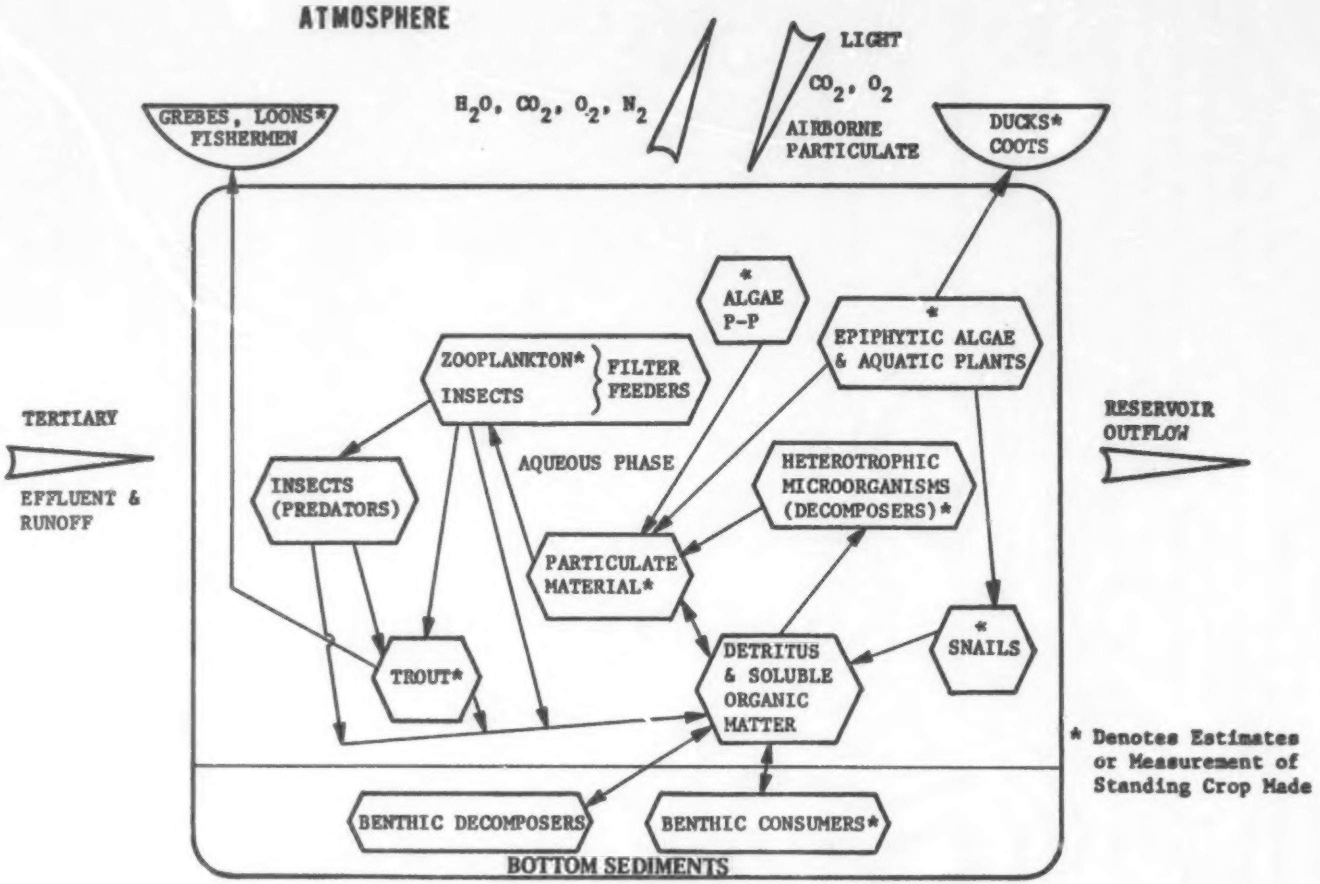

ATMOSPHERE
H_2O, CO_2, O_2, N_2
LIGHT
CO_2, O_2
AIRBORNE PARTICULATE
GREBES, LOONS* FISHERMEN
DUCKS* COOTS
TERTIARY
EFFLUENT & RUNOFF
RESERVOIR OUTFLOW
ZOOPLANKTON* INSECTS
FILTER FEEDERS
* ALGAE P-P
* EPIPHYTIC ALGAE & AQUATIC PLANTS
AQUEOUS PHASE
INSECTS (PREDATORS)
HETEROTROPHIC MICROORGANISMS (DECOMPOSERS)*
PARTICULATE MATERIAL*
TROUT*
DETRITUS & SOLUBLE ORGANIC MATTER
* SNAILS
BENTHIC DECOMPOSERS
BENTHIC CONSUMERS*
BOTTOM SEDIMENTS
* Denotes Estimates or Measurement of Standing Crop Made

Figure 23. Food web in ICR in simple form.

frequency of sampling and in the sophistication of the measurements of standing crop and diversity.

The results of these analyses are in Appendix 11 and are summarized in Table 7. Generally the results show very little pattern in terms of either numbers, species present or of the estimate of planktonic diversity. Apparently either the free living suspended microorganisms do not follow a pattern which relate simply to season or other parameters, or the measures are too crude to make good correlations. Undoubtedly both reasons are involved.

Table 7. CONCENTRATIONS OF ALGAE AND PROTOZOONS IN INDIAN CREEK RESERVOIR (DATA IN APPENDIX 11)

Sampling Date	Total Organisms per ml	Diatoms, Percent of Number	Number of Species Represented	Estimated Diversity[c]
1972				
May 30	272	32	14	2.32
June 19	48	[a]	9	2.07
June 26	580	37	15	2.20
July 16	880	16	15	2.06
July 31	2820	1	23	2.77
Aug. 14	1160	12	15	1.98
Aug. 28	2125	1	30[b]	3.79
Sept. 11	1175	12	19	2.55
Sept. 18	scan[a]	-	11	-
Sept. 25	765	28	24	3.46
Oct. 9	1330	27	17	2.22
Oct. 16	5985	-	31	3.45
Oct. 30	601	17	20	2.97
Nov. 13	683	34	20	2.91
Nov. 27	609	31	20	2.96
1973				
Mar. 24	2566	4	17	2.04
Apr. 23	463	7	8	1.14
May 7	890	6	17	2.36
May 21	840	2	17	2.38
June 4	2481	1	16	1.92
June 18	772	4	18	2.56
July 2	840	3	16	2.23
July 17	424	3	12	1.82

Table 7 (continued). CONCENTRATIONS OF ALGAE AND PROTOZOONS IN INDIAN CREEK RESERVOIR (DATA IN APPENDIX 11)

Sampling Date	Total Organisms per ml	Diatoms, Percent of Number	Number of Species Represented	Estimated Diversity[c]
Aug. 20	1053	8	19	2.59
Aug. 27	623	33	20	2.95
Sept. 10	377	20	12	1.85
Sept. 17	324	25	16	2.59
Oct. 1	381	29	15	2.36
Oct. 15	349	31	18	2.90
Oct. 29	1637	4	17	2.16
Nov. 13	scan	-	23	-
Nov. 26	374	23	16	2.53
Dec. 4	scan	-	11	-
1974				
Jan. 14	scan	-	15	-
Feb. 4	scan	-	15	-
Mar. 4	scan	-	9	-
Mar. 18	384	34	15	2.35

[a] Dashes indicate no data; scan indicates that only a quick genera count was made.

[b] Includes 7 ciliates; only 2 genera of ciliates noted on the 21 other occasions were observed.

[c] $D = (S - 1)/\log_e N$, S = Species number and N = total population. From [26] p. 55.

It is obvious that the planktonic numbers are more than sufficient to draw the conclusion that ICR is eutrophic. However, the diversity and the high clarity (Table 1) of the water at certain seasons of the year indicate that a well balanced planktonic producer level of organisms exists. Thus the initial energy level of the food web would be passed quickly to the consumer level. According to Margalef [27] the values are typical of low diversity ecosystems of relatively high productivity.

Bacterial estimates were made using plate counts on Plate Count Agar with sterile samples collected on October 20, 1972. The values, as do all plate counts, only give a rough indication of heterotrophic patterns in the reservoirs. Counts of colony forming units (cfu) ranged between 376 and 1273 cfu/mℓ at Station 3 and highest numbers were measured at the 0.5 meter depth and decreasing with depth to 6.5 m; no samples were collected near the bottom to prevent sediment bacteria from being counted. Two different colors of colonies were seen, yellow and cream, but the colonies were otherwise smooth edged and undistinguished. A surface sample collected at Station 1 had only 230 cfu/mℓ. Either depth or residual toxicity remaining in STPUD effluent reduced bacterial concentrations relative to Station 3.

Aufwuchs (mostly algal) were measured using glass slides placed in ICR during the period August 6-20, 1973. These results give an estimate of the maximum growth rate of aufwuchs (Figure 24). Over a two week period the growth apparently was still increasing. The maxi-

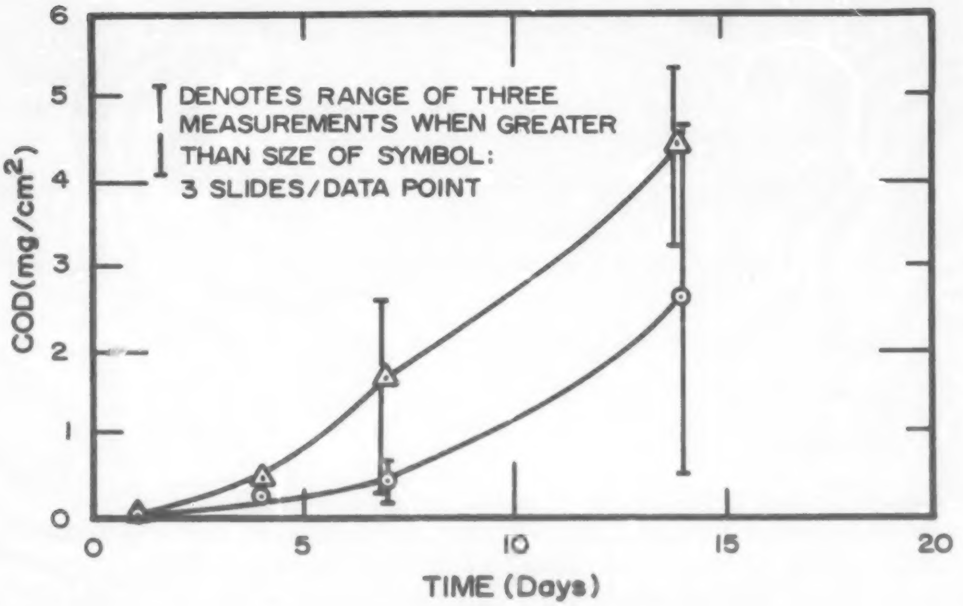


Figure 24. Growth of aufwuchs on glass slides in ICR, August 6-20, 1973.

mum growth rate ($\hat{\mu}_b = (1/\Delta t) \ln (X_i/X_{i-1})$) was estimated at 0.4 $days^{-1}$ (values for day 1 not utilized in calculation). Continuously lighted agitated flask cultures in the laboratory at about the same temperature as ICR generally have values of about 0.7 for ICR during times of high productivity (see next section, Algal Bioassays). If lighting conditions are taken into account, these results indicate that the attached organisms (mostly algae) are increasing in mass at about the same rate as would occur under laboratory conditions. Thus, aufwuchs as of August 1973 at ICR are at near maximum potential growth rates for the particular environmental conditions at ICR.

Algal Bioassays

Algal bioassays are used to estimate the biological effects of biostimulants and toxicants on potential algal growth and growth rates. Biostimulants for the test alga in this bioassay, Selenastrum capricornutum, essentially are all inorganic nutrients. The procedures have been described in Section IV and previously [4, 5, 8, 17]. The data for the bioassays are in Appendix 12.

As can be seen in Figure 25 the maximum specific algal growth rate in batch cultures ($\hat{\mu}_b = 1/\Delta t \ln (X_2/X_1)$ or $= 1/\Delta t \ln (X_3/X_2)$, whichever is greater) shows considerable variation with time in filtered ICR samples. With few exceptions little or no response was obtained with STPUD effluent (not graphed), a pattern which has been consistent throughout the study and which indicates residual toxicity. The toxicity is probably due to chlorine and chlorine compounds as the plant effluent is chlorinated when leaving the plant (see Appendix 9).

The particular pattern of response in the algal cultures is dependent on available nutrients. Thus the low growth rates in impounded water (Figure 25) observed in March through June 1972, September-October 1972, and September-October 1973 apparently correspond to periods of low nutrients.

One method of detecting whether the decrease in growth rate is caused by decreased nutrient content or by toxicity is to bioassay dilutions of the sample. If toxicity is present, dilutions will produce greater growth than the 100 percent sample as the toxicants become diluted. If no toxicity is present, dilutions will have less growth than the 100 percent sample as the nutrients become diluted. When toxicants and nutrients are both effectively decreased by dilution, the change in growth rate

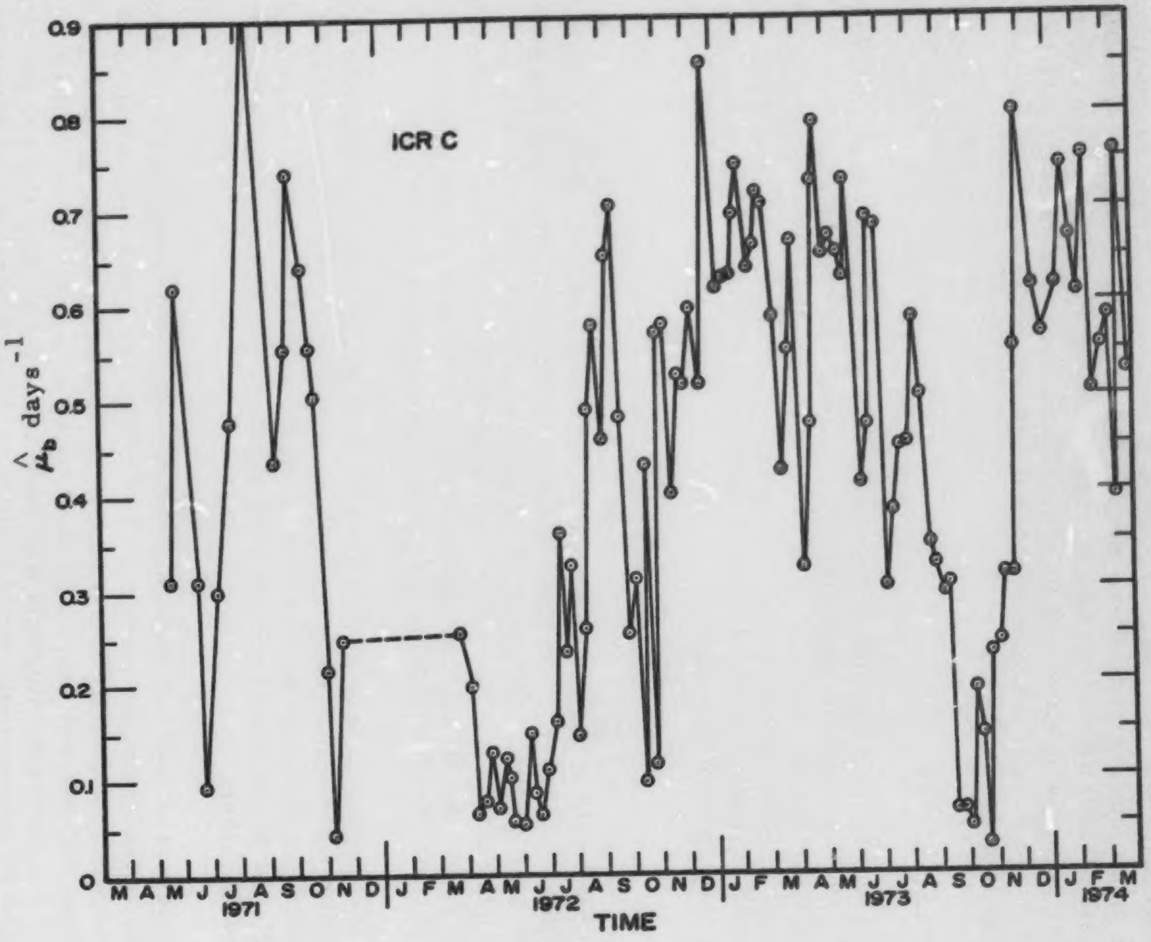


Figure 25. Variation in bioassay algal growth response in impounded water, ICR.

will lie in between the above two situations and some indication of toxicity can usually be determined.

The bioassay results of dilutions ([5], Appendix 12) indicate that STPUD effluent is almost invariably toxic as usually more growth was obtained with more dilution. The dilutions of impounded water have always indicated no observable toxicity; less growth was always obtained with greater dilution. Because the pattern of bioassay response seemed stable, dilution bioassays were discontinued at the beginning of 1972 and hence, the low responses for impounded water during the periods listed previously cannot be checked for toxicity. However, unless some unique happening were to have occurred, one would suspect that nutrient levels were low during those periods. The three periods noted do not correspond to other measurements within the system but visual observations suggest that high productivity, algae in the spring and vascular plants in the fall may have occurred and resulted in sufficient removal of nutrients to cause lower bioassay response.

An attempt to relate growth rates to nutrient concentrations is shown in Figures 26 and 27. The algal response to both STPUD effluent and ICR samples and their dilution are shown as a function of the nutrient concentrations in the sample. It is obvious that algal response to nutrients in STPUD effluent is low, indicating toxicity.

The algal response to impounded water samples has been fit with a Monod type line [8, 9]. The relationship between growth rate and phosphorus (PO_4-P) seems reasonable (Figure 26), while the relationship with inorganic nitrogen has an x-axis intercept of about 8000 μg N/ℓ (Figure 27) indicating that nitrogen was not limiting. Thus the algal bioassays indicate that phosphorus was probably a more limiting nutrient than nitrogen in ICR. Other factors such as light, turbidity, and predation probably control the phytoplankton population more than phosphorus. Trace metals and iron may be in short supply and help control the quantity and type of algae present. The high nitrogen levels prevent nitrogen from being limiting and thus no competitive advantage exists for nitrogen-fixing blue greens in ICR. The presence of other attached algae in large quantities Cladophora and Oscillatoria (just observed in quantity in 1974) seem to indicate that predation and not nutrients is a major factor in keeping phytoplankton at the observed relatively low densities. These algae will be discussed in the following section (Benthic Vegetation).

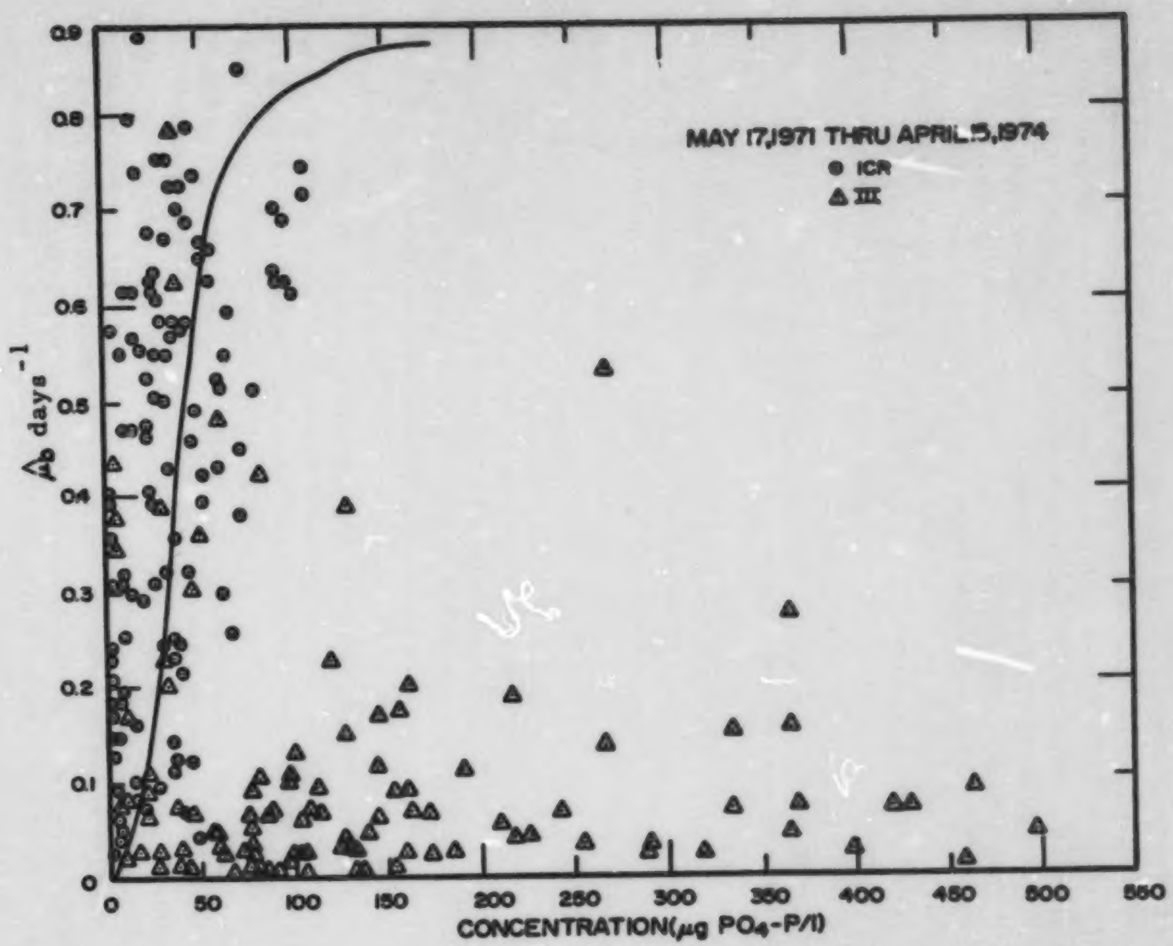


Figure 26. The variation in maximum specific growth rate batch (μ b) as a function of orthophosphate concentration in the bioassays, STPUD effluent (III) impounded water (ICR-C).

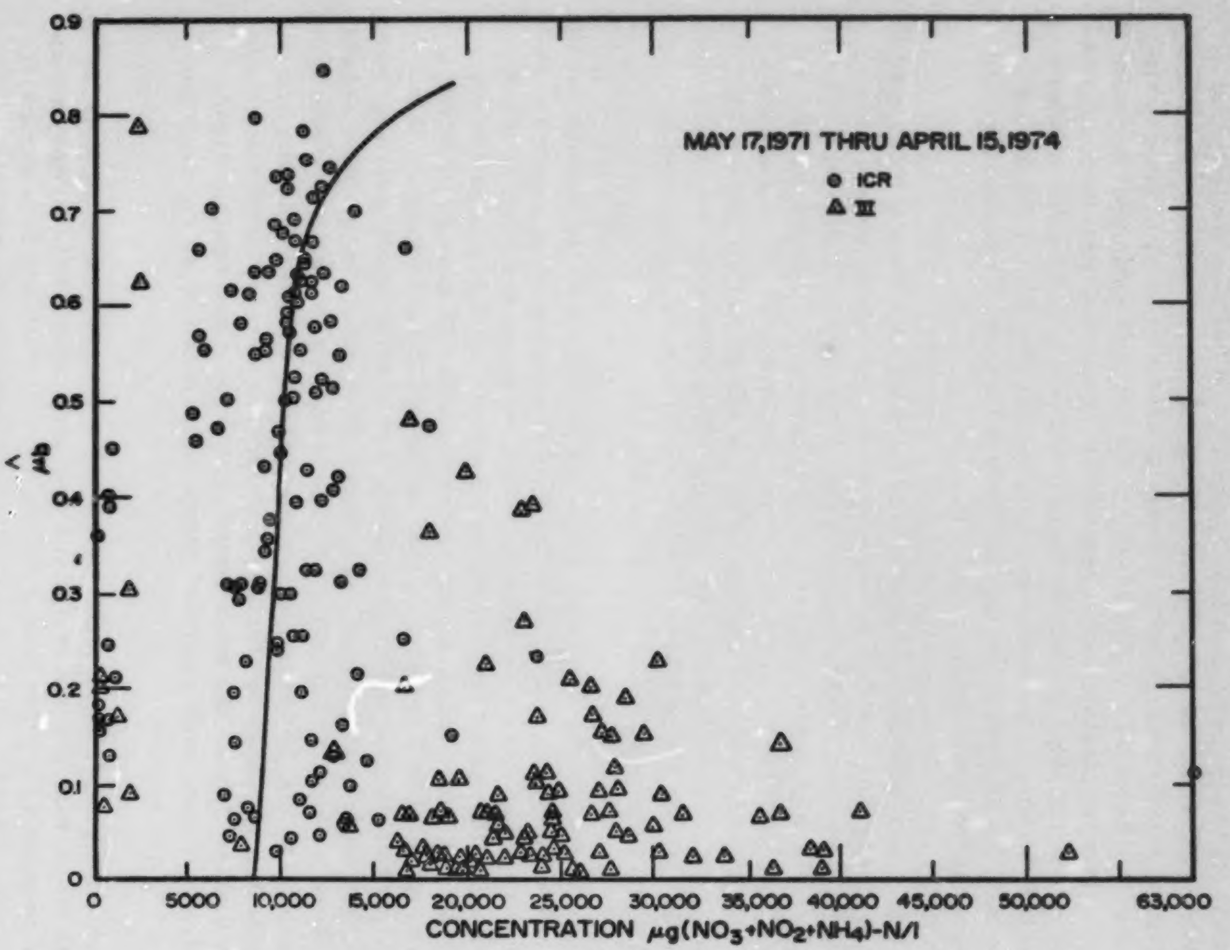


Figure 27. Apparent non-limiting relationship between inorganic nitrogen concentration in STPUD effluent (III) and impounded water (ICR-C) and maximum specific growth rate batch ($\hat{\mu}$b) in algal bioassays.

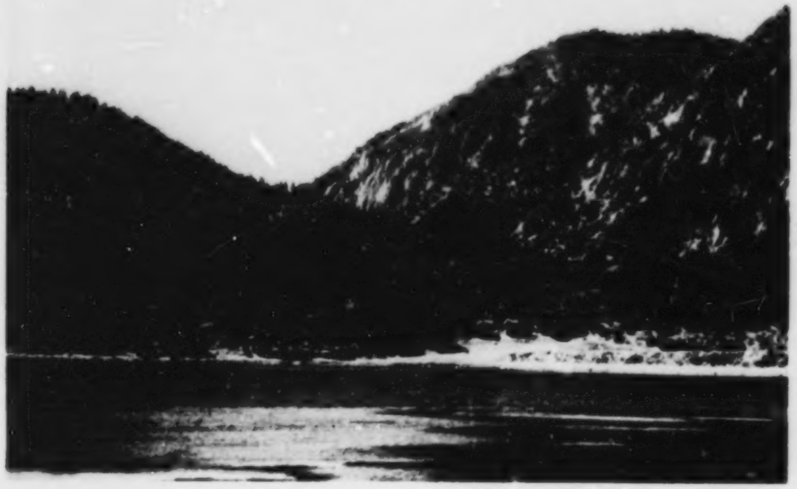
Benthic Vegetation

The growth of benthic and attached (epiphytic to benthic rooted plants) vegetation in ICR has developed into one of the most serious reservoir management problems. Aquatic weeds, periphyton, and algae growing on the mud surfaces of the bottom of the lake cover extensive areas of the lake. The vegetation interferes with recreational (fishing and boating) and aesthetic pursuits, contributes considerable organic matter which later degrades and decomposes affecting the dissolved oxygen balance in ICR, and probably has an impact on nutrient utilization and plant succession in the reservoir.

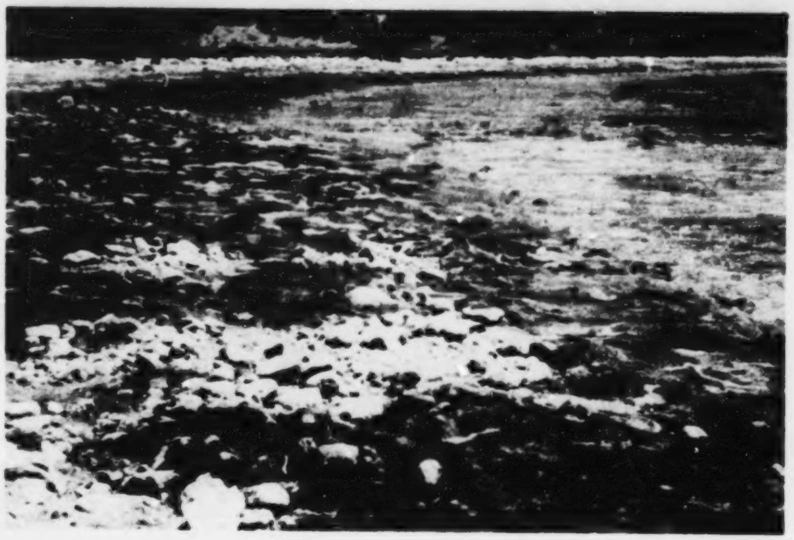
Vegetation types observed in ICR include: 1) aquatic weeds: *Myriophyllum*, *Ceratophyllum*, and *Potamogeton* as the principal weeds; also there have been observations of *Salvinia*, grasses and cattails; 2) periphyton; and 3) mud surface algae, almost entirely *Cladophora*. Photographs of the reservoir, various weeds, and some of the algae with notes on depth and location and distribution are shown in Figure 28. The photographs are of two types, either taken above the water surface by project staff or below the water surface by a diver employed by the project during July-August 1973 (Appendix 13).

The above water pictures vividly point out the effect of the aquatic weeds on the aesthetic value and uses of the ICR ecosystem (Figure 28A). As the water receded due to decreasing water levels dried mats of weeds, algae, snails and other organisms accumulated on the exposed shore (Figure 28B, C, D). Immediately offshore, mats of weeds and algae had built up because the water depth was insufficient to support the mass of plant material which previously had been actively growing there. At the same time that the reservoir water level decreased, peak Secchi depths were observed (Table 1). The resultant of those phenomena was that more light reached the reservoir substrate at deeper depths and the vegetation was able to colonize and grow at greater depths and over greater areas. Thus, the area covered by weeds and benthic algae probably increases each year as clarity improves and as colonization of deeper areas occurs.

In July and August 1973 an underwater survey of bottom conditions in ICR was made with the aid of a diver and underwater photography equipment (Appendix 13). The results of the survey resulted in a series of 35 mm color slides. Typical examples of these are reproduced as black and white prints (Figure 28). Also the vegetation on the reservoir bottom was analyzed resulting in the estimate of areas of vegetation as



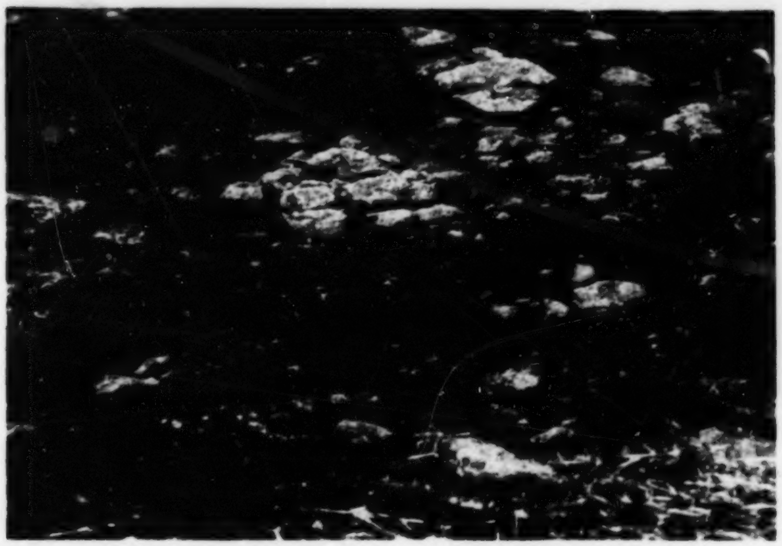
A. ICR, dam and milieu.



B. West Shoreline of ICR showing exposed and dried aquatic weeds.

Figure 28. Photographs of Indian Creek Reservoir, August 1973.

C. Close up of dried weeds with dead snail shells.



D. Shallow water on west shore showing Myriophyllum in foreground, floating algae, and rocks having periphyton (< 1 m).

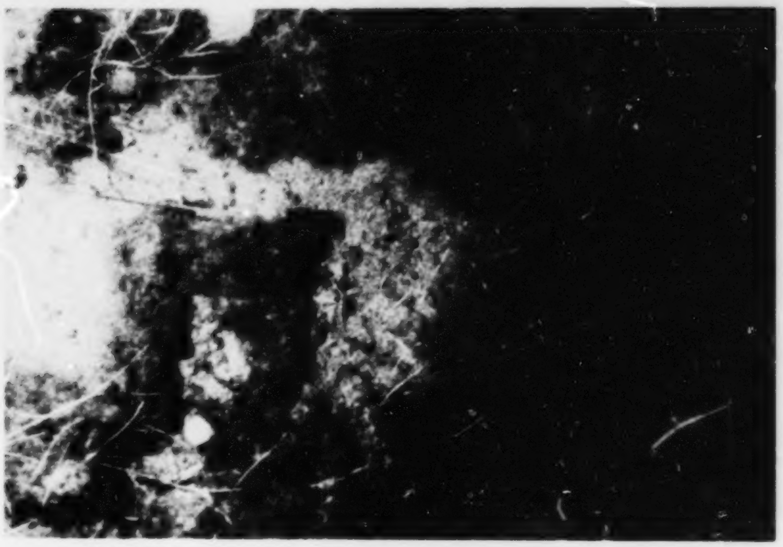
Figure 28 (continued). Photographs of Indian Creek Reservoir, August 1973.

a function of depth shown in Figure 29. The observed sharp interfaces of algae and silt (9 meters, 30 feet, deep) and weeds and no weeds (6 meters, 20 feet, deep) led to further analysis of the weed-algae distribution in ICR.

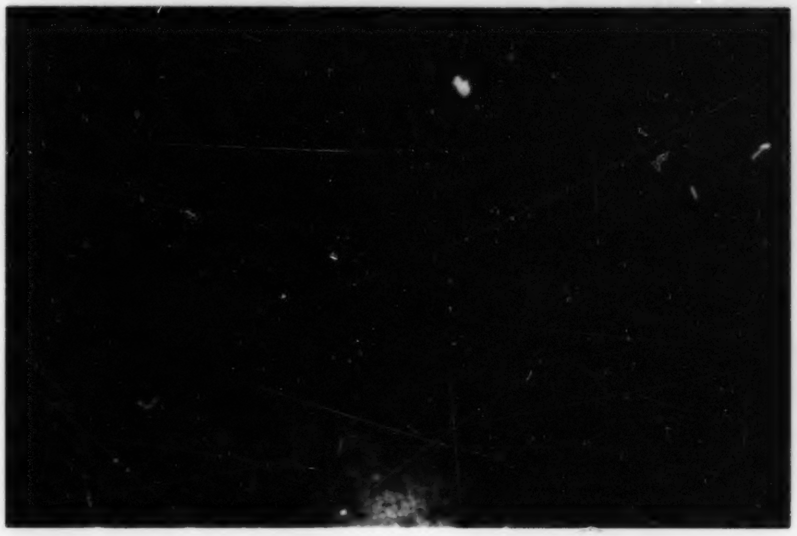
The August 8, 1973 survey showed that the aquatic weed populations extended to approximately the typical Secchi depth (Figure 28E, F). Cladophora extended into deeper waters approximating 1.5 times the typical Secchi depth (Figure 28G, H). Four zones were differentiated on the basis of depth and area (Figure 29): 1) exposed reservoir bottom (equals zero when the reservoir is full); 2) aquatic weed zone which extends from the shoreline to the Secchi depth; 3) the Cladophora zone which extends from the Secchi depth to 1.5 times the Secchi depth; and 4) the nonvegetated or silt zone. The interfaces between these zones are shown in Figure 28B, C, D, E, F, G, H for zones 1 and 2, 2 and 3, 3 and 4, respectively. Note that one of the aerator tubes (Figure 28I) is in deep water (silt bottom) and that the scale of the underwater pictures is about 50 cm (20 inches) (Figure 28J).

Obviously many assumptions and approximations are involved in such an analysis. For example, the bottom surface area is approximated based on the water surface area at the specific water depth. Because of temperature and instabilities in the Secchi depth (hence light penetration) during the late spring and early summer, the values are probably reasonable only during late summer and in fall when water temperatures and water clarity are fairly constant and sufficient to allow reasonable growth. These considerations become more evident in viewing the results shown in Figure 30 where the estimated area where extensive weed growth would likely occur is plotted as a function of time.

In late spring and early summer for all three years the weed area increases rapidly and then decreases as wind storms increase turbidity (also see data on Secchi disc in Table 1). Then a relatively stable period of maximum development of weed areas develops during summer and fall. Not only did the area available for weed growth increase from 1971 to 1973 but the time of maximum expected area of weed growth came earlier in the year; as would be expected from an analysis based on Secchi depth this coincided with the overall improvement in clarity as time progressed and with the earlier in the year that maximum clarity occurred as time progressed. Although these estimates are very approximate, visual observations and the increased need for weed

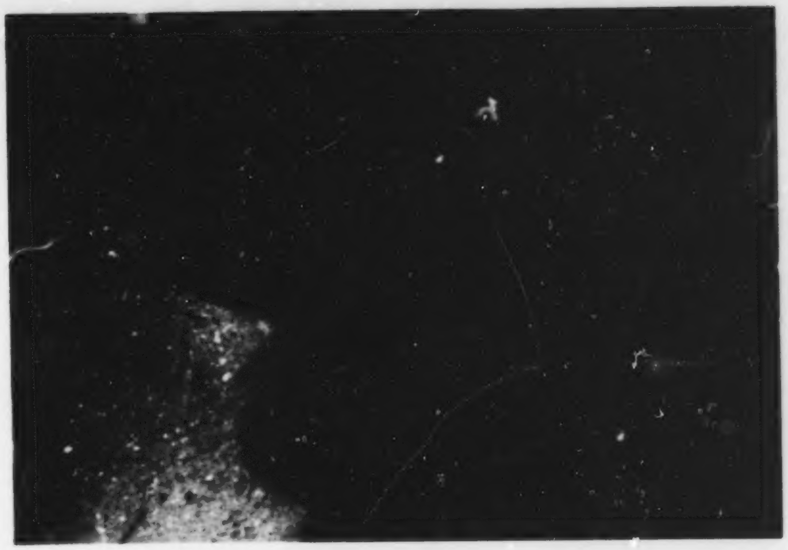


E. Myriophyllum and some Cladophora; interface at about Secchi depth (20 - 25 ft, 6.1 - 7.6 m).

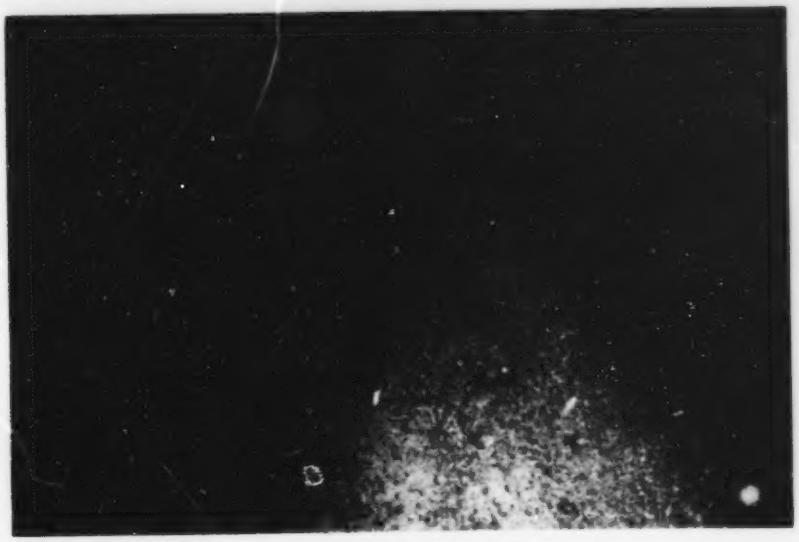


F. Myriophyllum and some Cladophora; interface at about Secchi depth (20 - 25 ft, 6.1 - 7.6 m).

Figure 28 (continued). Photographs of Indian Creek Reservoir, August 1973.



G. Cladophora and silt interface. Note extremely short stalked Myriophyllum invasion (30 - 35 ft, 9.2 - 10.8 m).



H. Cladophora and silt interface (30 - 35 ft, 9.2 - 10.8 m).

Figure 28 (continued). Photographs of Indian Creek Reservoir, August 1973.

I. Aerator line at 10.8 meters (35 ft). Note lack of plant growth.

J. Scale of underwater pictures; length of frame is 0.5 meters (20 inches).

Figure 28 (continued). Photographs of Indian Creek Reservoir, August 1973.

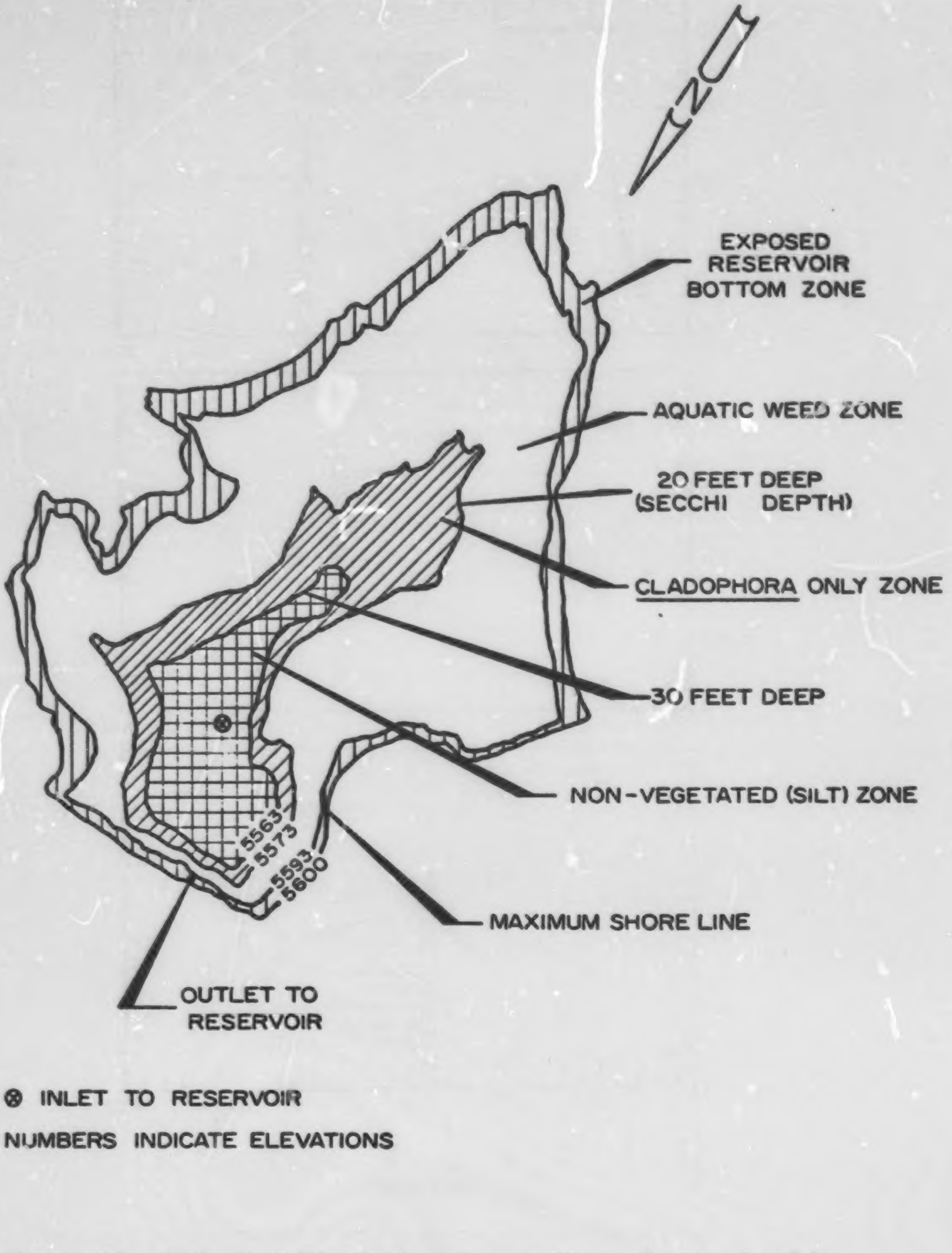

N
EXPOSED RESERVOIR BOTTOM ZONE
AQUATIC WEED ZONE
20 FEET DEEP (SECCHI DEPTH)
CLADOPHORA ONLY ZONE
30 FEET DEEP
NON-VEGETATED (SILT) ZONE
5563
5573
5593
5600
MAXIMUM SHORE LINE
OUTLET TO RESERVOIR
⊗ INLET TO RESERVOIR
NUMBERS INDICATE ELEVATIONS

Figure 29. Estimated distribution of vegetation and water level in ICR August 13, 1974.

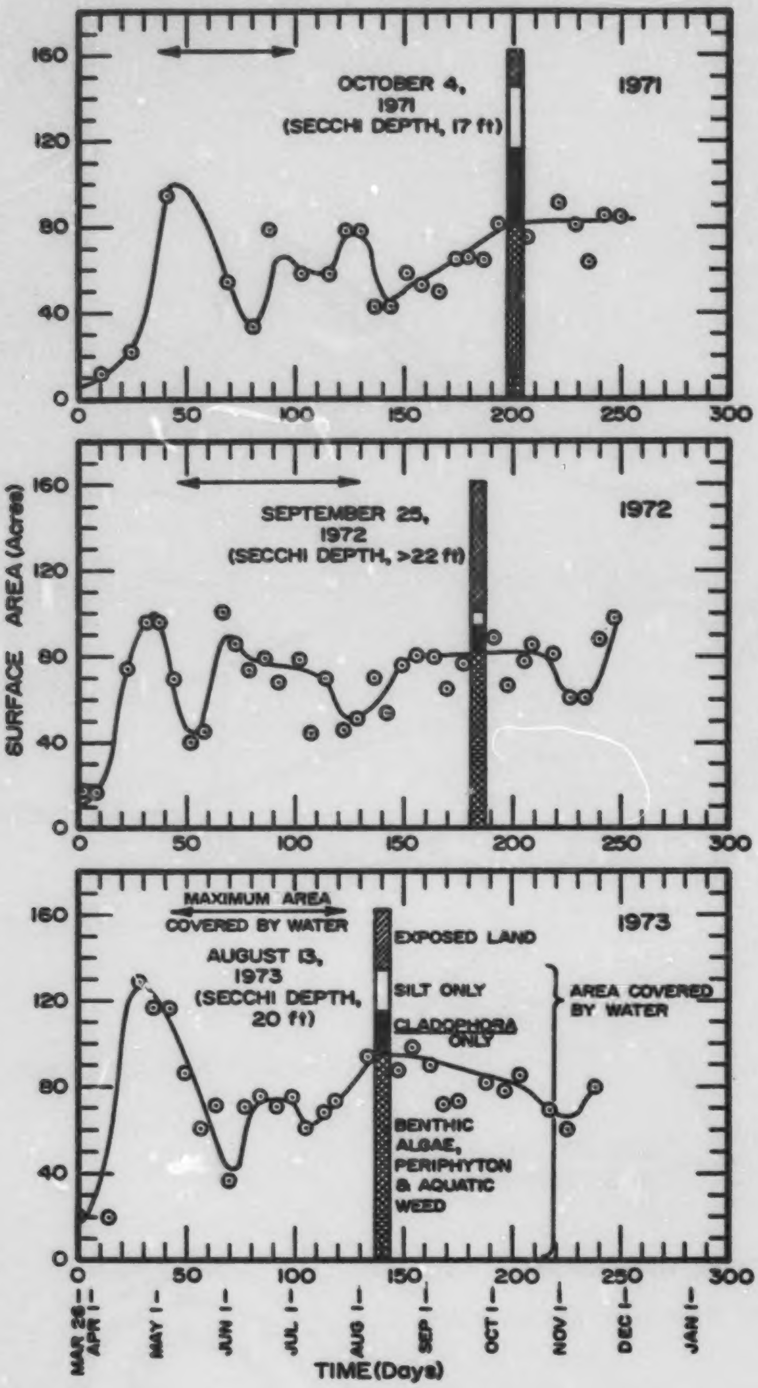


Figure 30. Estimated seasonal changes in reservoir area covered by aquatic vascular plants and benthic algae.

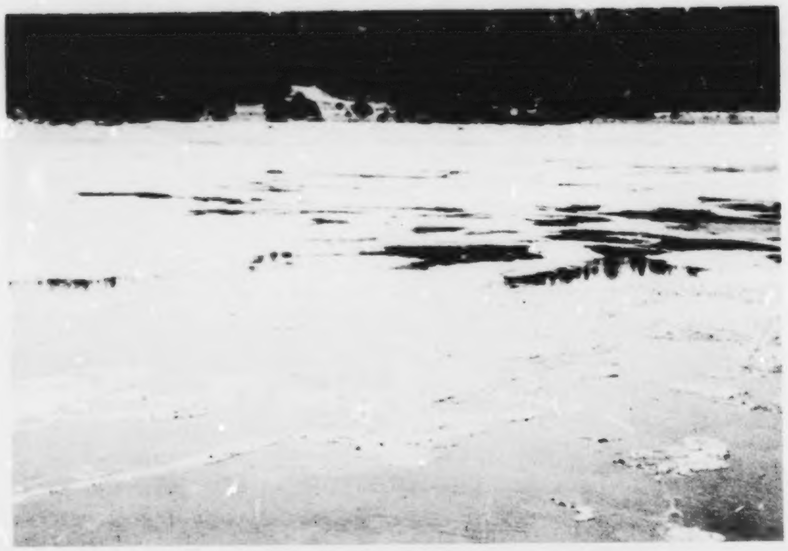
harvesting tend to confirm the analysis. Although the apparent maximum area of active weed growth occurred in May-June during all three years, this value was rejected as occurring over too short an interval and when temperatures would be low enough (16°C) to inhibit weed growth as compared to temperatures (20°C) later in the summer and fall (August, September, October).

Weed harvesting by the STPUD began in 1972 and continued through 1973 using a mechanical harvester rented from Dillingham Corporation. However, the most extensive harvesting occurred beginning right after July 4, 1974 and continuing until the middle of August. Using a mechanical weed harvester designed by STPUD (the "Dragon"), reportedly [28], over 100 truckloads (3-4 cubic yard capacity) of wet weeds were removed. However, extensive weed beds are still present both dried on exposed reservoir bottom and as weed banks along the shoreline.

At present (September 1974) these weeds are decomposing and creating a mechanical nuisance to fishermen and possibly supporting a dense growth of epiphytic blue-green algae, Oscillatoria (Figure 31). The algae in turn are leading to a noticeable taste and odor problem both in the air, the water and the flesh of trout caught by fishermen (see section on the trout fishery). The implications of the large blooms of Oscillatoria on the weeds, principally Myriophyllum, are that at least future taste and odor problems will occur. Whether or not cells will break off and become "planktonic" in high enough concentrations to interfere with existing food chains will only become apparent with further observation. If it does occur, the use of the eutrophic waters of ICR for recreation and irrigation will probably be severely inhibited.

Zooplankton

Although data are scattered, there has been an apparent general increase in population density (organisms/ℓ), biomass (dry weight, mg/ℓ), mean size (μg/organism), and diversity in Indian Creek Reservoir (see Table 8). The results indicate a gradual maturation of the reservoir although the diversity ($D = -\Sigma (n_i/N) \ln (n_i/N)$)[26] remains typical of highly productive impoundments. Sampling during the spring, 1972 indicates a higher stability in the zooplankton community with less variation in the diversity index than in previous years. The number of species detected reflect this increased diversity, being relatively constant.



A. Mats of dying algae--Myriophyllum.

B. Tube-like structures formed by Oscillatoria growing on dying Myriophyllum.

Figure 31. Oscillatoria epiphytic on dying Myriophyllum at shallow southern end of ICR, September 1974.

Table 8. CHANGES IN ZOOPLANKTON POPULATIONS SINCE SUMMER, 1970

Sampling Date	Tow[a]	Total Number of Organisms/l	Concentration Dry Wt mg/l	Mean Size μg/Organism	Number of Species	Number[b]		Diversity Index [26]
						of Daphnia	(% of Total)	
7/30-70	V	2.89	0.243	84	6	67	(18)	0.78
10/1-70	V	0.64	0.216	338	7	46	(55)	1.53
	H	0.14	0.014	100	5	4	(9)	1.18
10/14-70	V	-[c]	0.447	-	-	-	-	-
	H	-	0.013	-	-	-	-	-
12/9-70	V	0.88	0.342	389	3	113	(99)	0.66
	H	0.046	0.027	587	4	10	(67)	1.21
3/24-71	V	0.40	0.111	278	6	30	(59)	1.23
6/2-71	V	0.43	0.063	147	6	45	(80)	0.98
	H	0.80	0.067	84	14	115	(44)	1.79
6/12-71	V	0.45	0.367	816	6	17	(29)	1.43
	H	2.93	0.374	128	5	100	(10)	0.68
7/7-71	V	0.37	0.152	411	7	10	(21)	1.23
4/17-72	V	1.98	1.521	768	9	113	(44)	1.38
	H	1.52	0.161	106	11	61	(14)	1.27
5/8-72	V	2.13	1.129	530	10	192	(70)	1.34
	H	2.02	0.390	193	10	375	(57)	1.39
5/31-72	V	2.09	1.135	543	14	180	(67)	1.30
	H	0.82	0.616	751	5	204	(76)	1.09
7/10-72	V	1.11	0.315	284	6	30	(21)	1.35
	H	1.09	0.080	73	9	4	(1)	0.44
7/25-72	V	1.44	0.248	172	5	5	(3)	0.30
	H	1.22	0.107	88	6	10	(2)	0.28
8/8-72	V	0.91	0.258	284	3	28	(24)	0.61
	H	0.71	0.065	92	9	66	(28)	0.96

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[a] Vertical (V) Tow collected near Station 1 from reservoir bottom to surface through a column of 10-14 m depth (calculations based on mean of 12 m); Horizontal (H) Tow collected near Station 1 just beneath reservoir surface through distance of about 30.5 m.

[b] *Daphnia magna* and *Daphnia pulex*.

[c] Dashes indicate no analysis.

Generally, vertical tows had higher population densities, biomass, and mean size. This would indicate that considerable grazing (filter feeders, such as daphnids and ostracods) and predatory (copepods) activity occurred below the surface meter where the horizontal tows were made.

The diversity of both tows were about the same value generally. The phytoplankton diversity was slightly greater than for the zooplankton community but both values indicated productive aquatic systems.

Note that Daphnia appear to be most dominant during times when Secchi depths (Table 1) increase, indicating a possible cause-effect relationship, where Daphnia are filter-feeding and removing algae which have caused turbidity and decreased Secchi depth.

Invertebrates in ICR

Although many estimates of invertebrate organisms (egg masses, larval, and adult forms) were made in the progress of the study, the only quantitative measurements (excluding the protozoa and zooplankton results above) were made using bottom samples collected by a dredge. Samples collected in 1969 and 1970 were presented previously [5] and those collected in 1972 are in Appendix 14; the results are summarized in Table 9.

In the early project years an Ekman dredge was used for sampling. This type of dredge often loses many of the smaller organisms which float out as excess water drains from the dredge as it is returned to the surface. A Ponar dredge was used for the last set of samples. As can be seen in Table 9 for Station 1, the apparent effect of the two dredges was for the Ponar to increase the number of organisms but little difference was detected in the diversity estimated by the two sample types (for more data see Appendix 14). More careful analyses of the differences between the two dredges have been described elsewhere and the Ponar judged superior.

Because of this difference in sampling effect on numbers, conclusions cannot be drawn about the annual trends in population density of benthic invertebrates. If the ratio 620/290 for Station 1 in 1972 were to be correct, then it would be reasonable to assume that population density in 1972 would be about 300-350 thus indicating an approximation of steady state for the density of bottom organisms.

Table 9. SUMMARY OF BENTHIC ORGANISMS COLLECTED FROM INDIAN CREEK RESERVOIR[a] SEDIMENTS IN OCTOBER

Station Number	Number of Dredge Samples Collected	Average Number per Square Foot			Diversity[b]		
		1969	1970	1972	1969	1970	1972
1	(3), (5 in 1972)	412	588	290 (620)	0.35	0.93	0.96 (0.96)
2	(3)	588	160	(490)	0.70	1.2	(1.4)
3	(3)	528	392	(920)	0.72	1.4	(1.3)
4	(3)	648	260	(920)	0.36	1.4	(1.3)
5	(3)	268	160	(490)	1.05	1.9	(1.4)
6	(1)	364	120	(1400)	1.22	0.8	(0.88)
7	(1)	176	--[c]	(150)	1.02	--[c]	(1.89)
Mean		428	280	(713)	0.94	1.5	(1.3)

[a] Copepods and Cladocera not included in calculations. All samples collected with Ekman dredge except 1972 samples in parentheses collected by Ponar dredge (see Appendix 14).

[b] Diversity = $-\sum_{i=1}^{z} \frac{n_i}{N} \log_e \frac{n_i}{N}$ in which, n_i = number of individuals in a particular species and N = the total number of individuals in all species [26].

[c] No sample collected.

This argument is supported by approximately the same diversity for the different stations. Station 6 has a low diversity primarily because about one-half the number of organisms is the planorbid snail, Gyraulus parvus. Station 7 has high density which might be expected because of its location in a shallow shoreline area having many aquatic vascular plants, algae, and also wave turbulence to introduce oxygen. This hypothesis is supported by counts of organisms obtained from rock scrapings, Station 8, and from the reservoir outlet stream, Indian Creek, where high population densities and diversities were seen (Appendix 14).

As in all previous years the results show that both numbers and diversity increase with distance from Station 1. This observation could result from moving from deep to shallow waters but it is likely that toxicity and lack of dissolved oxygen are involved in limiting Station 1 populations near the outfall of the STPUD effluent.

Large numbers of ephippia were collected in the dredge samples. In the reservoir, estimates varied between 51,667 to 441,324 per m^2 (4800 to 41,000 per square foot) and averaged 172,224 per m^2 (16,000 per square foot). These wintering egg estimates of densities indicate a great amount of daphnid zooplankton productivity.

Several invertebrates new to ICR have been detected in 1972 which were not found previously. These include most notably the amphipod, Hyallela azteca, and the gastropods, Gyraulus parvus and Planorbella subcrenatum. It is not likely that the gastropods at least were detected only because the Ponar dredge was used.

The role of snails in aquatic weed control and in the ecosystem generally is not clear. There are extremely large numbers of snails in the system and counts of snail shells in dried weeds along the exposed shoreline were in the range of 200-400/m^2 in 1971 [5] and about 500/m^2 in August of 1973. It is not known if the snails represent a significant drain on the weed productivity but because of the nutrient excess in the lake, this is unlikely. The snails do represent a significant part of the feed for larger trout as evidenced by fish stomach analyses [5, 29].

Trout in Indian Creek Reservoir

The history of fish plantings in Indian Creek Reservoir reveals much information concerning the maturing of the reservoir with time. During the summer of 1968 trout were placed in test boxes in the reservoir water but failed to survive for longer than 24 hours, some dying within 30 minutes. To test the reservoir environment further 2,080 rainbow trout fingerlings 7.6-10.2 cm (3-4 inches) long were planted in the reservoir on October 16, 1968, some 6 months after filling of the reservoir began. No mortality was observed during the fall months but by springtime no fish apparently remained. Fish mortality was presumed to be due to a lack of dissolved oxygen caused by prolonged heavy ice cover of the water surface during the winter of 1968-69, although this presumption was not fully proven.

On August 8, 1969, 3,600 hybrid (rainbow and cutthroat) trout 4.3 cm (1.7 inches) in length were planted in the reservoir. Three days later 4,400 trout of the Hat Creek (Mono County) rainbow strain were planted. These were some 11.4 cm (4.5 inches) in length. An overnight gill netting operation on October 1969 produced a catch of 130 of these fish. By that time the small fingerlings had grown to 15.2 cm (6 inches) in length and the second group averaged 22.6 cm (8.9 inches) long. Subsequently, in March 1970, a one-day gill net setting yielded 18 fish most of which were 27.9 cm (11 inches) long, the smallest being 24.5 cm (10 inches). Thus, the reservoir food chain resulted in excellent growth rates of the trout and indicated that the reservoir was very productive. Plantings and fishing success are summarized for available data in Table 10. Only trout have been planted at ICR and no other species have ever been reported.

Obviously something occurred during the reservoir's development which made it compatible to trout. Although the exact cause of mortality of fish in the 1968 tests is not known, some toxic factor was evidently present. Inasmuch as the recommended limit for ammonium at normal outdoor values of pH is 2.5 mg/ℓ for trout, free ammonia toxicity seems the most logical cause of fish mortality at that time [30], the influent to the reservoir having an ammonium concentration of from 12 to 20 mg/ℓ. The most important factor in fish survival must then be the phenomenon which reduced the concentration of ammonium in the impounded water from these high values to values ranging from 2.5 to 7.0 mg/ℓ in subsequent months, a level which will apparently not affect fish at the pH's common in the reservoir. As previously noted, dilution alone was not the cause of nitrogen reduction but rather nitrification.

The effect of ammonia-ammonium toxicity is extremely important in discussing the disposal of wastes in east slope Sierra waters [30] and if the balance is upset in some way, the trout population shows a rapid response. The Tahoe Daily Tribune (South Lake Tahoe, Calif.) of March

Table 10. THE TROUT FISHERY IN INDIAN CREEK RESERVOIR[a]

Year	Fish Stocked		Creel Census							
	Finger-lings	Catchable and Sub-catchable	Success Rate, Number/hr	Anglers		Days Sur-veyed	An-gling Hours	Num-ber Caught	Size, inches	
				Boat	Shore				Range	Ave.
1971 Totals	117,696	33,600	0.15	139	647	9	2627	402	6.4 to 18.5	11.6
No./day	-	-	-	15	72	-	314	45	-	-
1972	36,700	0	0.23	75	176	9	736	169	10.2 to 19.6	13.1
			-	8	20	-	82	19	-	-
1973	37,280	119 (spawning)				no data				
1974	65,000	0				no data				
Totals	256,676	33,719								

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[a] Data courtesy of Russ Wickwire, Fishery Biologist, Calif. Dept. of Fish and Game [29].

13, 1972 reported that about 5,500 trout some of which weighed up to 1.8-2.3 kg (4-5 lbs) each had died and this coincided with the beginning of the higher than normal discharges of ammonium in spring and summer 1972 (see Figure 16). Unfortunately the laboratory was temporarily closed at this time, being between funding periods. The California Fish and Game judged that fish kill was probably caused by free ammonia (Appendix 15).

Thus, two conclusions are supported by the experience with trout in Indian Creek Reservoir:

1. That the establishment of a balanced ecosystem in which ammonia toxicity was not a problem was necessary before the water became a suitable environment for trout.

2. The control of free ammonia through limitation of the amount of ammonium nitrogen discharged and productivity control to prevent high pH (ammonia and pH relationships are shown in 31) are necessary to prevent further occurrences of this type.

At present the trout fishery at ICR is going well and many fishermen are present at all seasons (see Table 1). The aquatic weed growth is causing problems by physically interfering with fishing. In September 1974 it was observed that a significant earthy odor was present at the reservoir and it was observed that trout were tainted with an earthy taste. This taste and odor problem is apparently due to the presence of epiphytic Oscillatoria blooms; this problem will undoubtedly interfere with recreation especially fishing at ICR.

SECTION VI

DISCUSSION AND EVALUATION OF RESULTS

Evaluation of specific findings of environmental, chemical, and biological observations of Indian Creek Reservoir is included in Section V as a part of the interpretation and discussion of the individual subjects therein presented. Conclusions are drawn in that section as deemed appropriate by the authors. These are summarized and extended in Section I, and recommendations are summarized in Section II. Therefore it seems appropriate to consider in this section what the Indian Creek Reservoir study has thus far shown concerning the reclamation of water from domestic wastes for recreational use and its import in the context of eutrophication of surface waters, as well as the changes observed with time in the impounded water itself.

In evaluating the results of the study herein reported it must be borne in mind that although Indian Creek Reservoir was providing recreational opportunity in the form of sport fishing and development for contact sports is contemplated, it was adapted rather than designed for such purpose. This is to say that the processes to be applied to secondary waste water effluent at the South Tahoe Public Utility District Plant were not originally selected with the objective of producing a water quality ideally suited to the multiple beneficial uses which are compatible in a wilderness. Instead they were the outgrowth of concern on the part of water quality control officials for the consequences of fertilizing surface waters with nutrients added by domestic use of water - nutrients which are only stabilized and not removed by the best, or even perfect, sewage treatment plants of the conventional type. Overriding even this national problem, and the national objective of its solution, was the unique situation existing in the Lake Tahoe Basin. Here it was deemed unacceptable, and on good evidence, to discharge into Lake Tahoe even water which meets U.S. drinking water quality standards, because in the matter of nutrients such standards exceed by some two orders of magnitude the concentrations presently found in the lake.

The factors underlying process design were therefore based on a number of rational concepts, not all of which were necessarily explicit in the decisions which followed:

1. The time is at hand when in many circumstances conventional waste water treatment processes must be extended to include nutrient removal or reduction.

2. Phosphorus is capable of triggering objectional algal growths when low oxygen concentrations encourage algal species capable of utilizing nitrogen from the atmosphere .

3. We know how to remove phosphorus, therefore in the course of "pollution control" it should be removed as an act of faith if not of scientific necessity.

4. Nitrogen removal, although not immediately technologically developed, must in the future likewise be applied to waste water effluents.

5. At the present state of technology and knowledge of the sensitivity of Lake Tahoe, even the most highly treated waste water cannot be allowed to enter the lake, either directly or indirectly. Therefore, export from the basin is a practical necessity.

6. Given present aesthetic attitudes of people, exported effluents must be good enough to be acceptable to the exporter himself under normal conditions, i.e., were it not for the unique quality of Lake Tahoe.

7. Emerging standards of both surface and ground water quality must be met by any process of water reclamation.

8. A pioneering task of process development has to be undertaken if other concepts of water quality are to be achieved.

Given objectives, constraints, and problems such as the foregoing, and the political climate in which they must be resolved, the objectives of process design were necessarily different than might have been the case had the creation of a recreational reservoir been the water quality objective. This fact is extremely important in understanding what has been observed at Indian Creek Reservoir; and in considering what observations are required for the future.

The data herein presented show quite clearly that the reclaimed water delivered to Indian Creek Reservoir during its first three years of operation were so low in phosphorus as a result of purposeful phosphate removal by the South Tahoe Public Utility District as apparently to be phosphate limited with reference to nitrogen, as an algal growth medium. That is, it contained nitrogen in excess of phosphorus in some 10 times the N/P ratio at which algae utilize these two nutrients, while at the same time approaching the concentration (0.10 mg/ℓ) of phosphorus at which less than eutrophic conditions might be expected to occur. Moreover, in its undiluted state STPUD effluent was toxic to both trout, in the early years, and the test alga (Selenastrum) used in bioassays of its growth potential. It was tentatively concluded early in the study that free ammonia was the toxic factor for the trout. Later it became apparent that in the impoundment this same water lost ammonium-nitrogen from its initial 15 to 20 mg/ℓ concentration in STPUD effluent to a level generally less than 4-6 mg/ℓ.

That the observed profound change in ammonium content was not due to simple dilution was shown by a hydrological balance which revealed the reservoir input to be increasingly reclaimed water from STPUD (up to 80%) and decreasing surface runoff (down to 20%) and rainfall directly on the reservoir water surface. That it was not due to nitrification alone was likewise evidenced by the failure of nitrates to reach any sustained levels above about 6 mgN/ℓ.

Loss of nitrogen from the reservoir by nitrification-denitrification was early suspected as the cause of the observed nitrogen imbalance. From the evidence developed in the study there is no doubt but that nitrification in the hypolimnion and denitrification in the benthic zone is the major mechanism. Analysis of the benthic sludge in 1971 [5] revealed the presence of denitrifying bacteria in numbers characteristic of a healthy denitrifying sludge. Similarly, direct experiments showed nitrification activity in the hypolimnion during the summer months sufficient to account for the nitrogen lost by denitrification [5]. Aeration of the reservoir by mechanical means, however, gives reason to believe that the benthos is the site of denitrification activity.

The efficiency of removal of phosphorus by the STPUD reclamation plant varied during the study as did ammonia removal; but high N/P ratios were observed at all times in the reservoir. Other possible sources of phosphorus include the original soil on which the reservoir was constructed, animal and plant wastes washed in from the small (1700-acre) drainage area, and such allochthnous material as wind blown dust and pollens. Although these sources might conceivably be considered minor, they could add to a buildup in the benthic sludge.

The extent to which phosphate limitation is responsible for the apparent good quality of Indian Creek Reservoir should be further studied in relation to sources of phosphorus in order that the true value of phosphate removal as a waste water treatment process may be determined. In the specific case of the Indian Creek Reservoir, where the annual discharge represents a large percentage of the reservoir capacity, biological recycling may be either more or less important than in larger lakes, depending upon where the phosphorus is in the system at the time of water releases. The loss of phosphorus largely to benthic sludge indicates that phosphorus cycling is not too important.

Biologically, Indian Creek Reservoir showed important changes over the five year study period. From an initial situation in which it apparently would not support fish life, it developed into an excellent trout fishery. However, the fish production, as measured by early season catches, appeared to have declined. Gill netting studies indicated that this might not be the case. In view of somewhat contradictory, albeit fragmentary evidence, such as the nitrogen increase and the question of over availability of feed for the fish and the fish population itself, it is clear that ICR should be monitored for a longer period to determine whether the reservoir fishery will support the large number of fishermen interested in the reservoir.

Evidence that with time the reservoir increased rather than decreased in biological health is to be found in an increase in the diversity of benthic invertebrates. This diversity was the more convincing because of a decline in the predominance of low oxygen tolerant species of chirnomids. The extent to which this was the result of mechanical aeration of the water is uncertain but it is well established that such aeration of water will not preclude an anaerobic zone in the underlying sludge or soil. This is further specifically evidenced in Indian Creek Reservoir by denitrification activity traceable to the benthic sludge.

Plankton in the impounded water, as well as the emergence of a normal cycle of algae and grazers (Daphnia) in the impounded water likewise suggests an improving limnological situation.

Bioassays of impounded and reclaimed water were especially revealing of the maturation of Indian Creek Reservoir. The cyclical nature of growth response, as measured by the specific growth rate $(\hat{\mu}_b)$ of *Selenastrum*, showed that the growth potential of the impounded water decreased during the growing season when the biota of the reservoir were utilizing the nutrients. In contrast, no such cyclical response was clear in the reclaimed water and toxicity to algae masked the effects of high nutrient content as shown by the dilution bioassays.

This cyclic finding is logical and is particularly important because it differentiates between the growth potential and the residual growth potential of a water. This is to say that a bioassay of a waste water (filtered) may reveal its true algal growth potential (within the limits of capability of the test), whereas in an outdoor body of water it can only measure the residual potential in the water. In wintertime more of the total potential of an impounded water might be in undecomposed organic matter in the benthic sludge than in the water, whereas in the summer time the reverse may be the case. But in any case a bioassay must be interpreted with caution when applied to a natural body of water. Conceivably, an extremely highly eutrophied body of water could show little response because the test utilizes only that fraction of the nutrients currently being recycled between decomposing and growing biota. In contrast, a filtered waste water, or the reclaimed water influent to Indian Creek Reservoir, harbors no nutrient sinks such as those in a lake or reservoir. In this circumstance the lesser growth shown by reclaimed water than by the impounded water indicates clearly that Indian Creek Reservoir as a limnological entity is influenced by many factors not implicit in the mere quality of its principal source of influent. For example, apparently there is a detoxification mechanism in ICR which removes the toxicity in STPUD effluent.

Productive biological systems represent complex interactions between physical, chemical, and biological phenomena. ICR is a productive reservoir with waters containing high nutrient concentrations which can only be defined as being at eutrophic levels.

Because of its large area of relatively shallow waters the reservoir has extensive areas covered by aquatic vascular plants, i.e. weeds. The weed problem has important ramifications for the expansion of recreational uses in the reservoir; however, future such reservoirs could avoid this weed problem by morphological design changes to produce an overall deeper reservoir. In general the reservoir water is of high quality to the casual viewer and this is because of the high water clarity. This observation generates the question of why there are not greater algal populations in ICR which would cause a readily apparent problem to the average recreationalist.

Obviously, the types of algae does not include the typical nuisance algae found in eutrophic lakes, i.e., blue-green algae. Nitrogen-fixing blue-green algae do not occur in ICR probably because there would be no competitive advantage for nitrogen fixers in the high nitrogen environment of ICR. In addition, nitrogen fixation is inhibited by high concentration of nitrogen [32]. However, populations of other blue-greens are not developing either [33]. Probably other algal groups are more subject to predation than most blue-green algae and it appears that predation is preventing the development of algal blooms in ICR. Then the central question about ICR is why are large populations of blue-green algae not present in ICR?

Observations about nutrients and other chemicals in ICR suggest several possible reasons for the lack of blue-green algal blooms: 1) There is an unusual nutrient relationship in ICR where inorganic nitrogen concentrations are 300-400 times the orthophosphate concentrations in the reservoir, does the high N/P ratio select for other algae over blue-greens?; 2) Are the high ammonium concentrations toxic to blue-greens?; 3) Apparently metals concentrations are relatively low and these may be limiting to blue-greens; and 4) Organic carbon concentrations entering the reservoir are quite low when compared to typical eutrophic reservoirs receiving sewage effluents and organics may be necessary for blue-greens; the presence of the blue-green alga, *Oscillatoria*, as an epiphyte on the aquatic weed, *Myriophyllum*, suggests that the *Oscillatoria* may require organic compounds secreted by *Myriophyllum.* Obviously other factors than the presence of *Myriophyllum* are involved, but until September 1974 no large populations of blue-green algae had been observed in ICR. The implications of the possible incipient blue-green bloom in ICR for algal succession and for the development of ICR as a recreational resource are extremely important to water quality management.

Other interactions of interest to other investigators concern nutrient cycling where the question of phosphorus-iron (and other metals), calcium precipitation should be considered in more detail. Nitrification-denitrification, although originally having a significant effect on dissolved oxygen, does not affect it at present, however, the process apparently prevents even greater buildups of nitrogen compounds than occur there at present.

The role of nutrient cycling in maintaining succession and productivity in ICR is not clear and although the reservoir is clearly eutrophic, the nutrient ratios must be involved in the types of organisms present and thus be involved in control of the phytoplankton standing crop.

In an overall evaluation of Indian Creek Reservoir it might be said that the impoundment affords an unprecedented opportunity to observe, for practical as well as scientific reasons, what may be expected from a ponding of water reclaimed from domestic return flows. As noted in the opening paragraphs, no attempt was made originally to design the waste water reclamation plant at South Tahoe to produce a water of optimum quality for recreational purposes, if indeed such an optimum could be defined. Eventually, however, the data from Indian Creek Reservoir should indicate whether such an optimum process would be appreciably different than that presently installed at STPUD. In the meantime it may be said that the STPUD plant is a very efficient system for removing phosphorus, and Indian Creek Reservoir is a good system for removing nitrogen. Whether or not the level of phosphorus removal is presently effective, is the controlling factor, or is of little consequence is an important practical and economic question.

The blue-green algal and aquatic weed problems as they affect quality in ICR and its recreational - aesthetic use still remain to be evaluated. Unless these current problem trends reverse it is apparent that the reservoir will not be as useful for recreation as previously supposed. This observation should not be taken to imply that the STPUD - ICR project has failed; the development of irrigation downstream of ICR has shown the value of reclaimed water and the necessity of recycling - taking and using a product which previously society discarded.

SECTION VII

REFERENCES

1. McGauhey, P. H., E. A. Pearson and G. A. Rohlich. Comprehensive Study on Protection of Water Resources of Lake Tahoe Basin. Lake Tahoe Area Council, South Lake Tahoe, Calif., 95705. 1963.

2. South Tahoe Public Utility District. Feasibility Report on Indian Creek Reservoir. Clair A. Hill and Assoc., Consulting Engineers, Redding, Calif. 1968.

3. South Tahoe Public Utility District. South Lake Tahoe Water Reclamation System. Brochure. Undated - obtained in 1969.

4. McGauhey, P. H., D. B. Porcella, G. L. Dugan and E. J. Middlebrooks. Eutrophication of Surface Waters--Indian Creek Reservoir. FWQA First Progress Report for Grant No. 16010 DNY, LTAC, South Lake Tahoe, Calif., 95705, 141 p. 1970.

5. McGauhey, P. H., D. B. Porcella and G. L. Dugan. Eutrophication of Surface Waters--Lake Tahoe: Indian Creek Reservoir. EPA - 16010 DNY 07/71, U.S. Supt. of Documents, Washington, D.C., 115 p. 1971.

6. American Public Health Association. Standard Methods for the Examination of Water and Wastewater. 12th Ed., New York. 1965.

7. Strickland, J. D. H. and T. R. Parsons. A Manual of Sea Water Analysis. Bulletin No. 125, Fisheries Research Board of Canada, Ottawa. 1965.

8. McGauhey, P. H., G. A. Rohlich, E. A. Pearson, M. Tunzi, A. Adinarayana and E. J. Middlebrooks. Eutrophication of Surface Waters--Lake Tahoe: Bioassay of Nutrient Sources. FWPCA Progress Report for Grant No. WPD 48-01 (R1), 178 p. 1968.

9. McGauhey, P. H., G. A. Rohlich, E. A. Pearson, E. J. Middlebrooks, D. B. Porcella, A. Aleti and M. Tunzi. Eutrophication of Surface Waters--Lake Tahoe: Laboratory and Pilot Pond Studies. FWPCA Second Progress Report for Grant No. WPD 48-02, LTAC, South Lake Tahoe, Calif., 95705, 180 p. 1969.

10. Porcella, D. B., J. S. Kumagai and E. J. Middlebrooks. Biological Effects on Sediment-Water Nutrient Interchange. J. San. Eng. Div. ASCE, 96:911. 1970.

11. Maciolek, J. A. Limnological Organic Analyses by Quantitative Dichromate Oxidation. Bureau of Sport Fisheries and Wildlife, Research Report 60, Washington, D.C., 61 p. 1962.

12. Skulberg, O. M. Algal Cultures as a Means to Assess the Fertilizing Influence of Pollution, Advances in Water Pollution Research. Water Poll. Cont. Fed., Washington, D.C. 1:113. 1967.

13. Gonzales, J. Personal Communication. STPUD, South Lake Tahoe, Calif. 1974.

14. Medsker, L. L., D. Jenkins and J. F. Thomas. Odorous Compounds in Natural Waters. Env. Sci. and Tech., 2:461-464. 1968.

15. Culp, Russell L. Monthly Reports to the Lahontan Regional Water Quality Control Board. STPUD, South Lake Tahoe, Calif. 1968-1974.

16. McGauhey, P. H. and R. B. Krone. Soil Mantle as a Wastewater Treatment System. Final Report, Sanit. Eng. Res. Lab. Report No. 67-11, Berkeley, California. 1967.

17. McGauhey, P. H., G. L. Dugan and D. B. Porcella. Eutrophication of Surface Waters--Lake Tahoe. FWQA, Final Report for Grant No. 16010 DSW. LTAC, South Lake Tahoe, Calif., 95705, 141 p. 1971.

18. Eldridge, E. F. Return Irrigation Water--Characteristics and Effects. DHEW, U.S. PHS Region IX, Portland, Oregon, 119 p. 1960.

19. Bernstein, L. Salt Tolerance of Plants. Agricultural Information Bulletin 283, U.S. Department of Agriculture. 1964.

20. Sawyer, C. N. Fertilization of Lakes by Agricultural and Urban Drainage. J. New England Water Works Assoc., 61:109. 1947.

21. Saunders, G. W., F. B. Trama and R. W. Bachman. Evaluation of a Modified ^{14}C Technique for Shipboard Estimation of Photosynthesis in Large Lakes. Great Lakes Res. Div., Inst. Sci. and Tech., Univ. Mich. Publ. No. 8:1-61. 1962.

22. Porcella, D. B., P. H. McGauhey and G. L. Dugan. Response to Tertiary Effluent in Indian Creek Reservoir. Journal WPCF, 44:2148-2161. 1972.

23. Stumm, W. and J. O. Leckie. Phosphate Exchange with Sediments; Its Role in the Productivity of Surface Waters. Presented at the 5th International Water Poll. Res. Conf., San Francisco, 16 p. 1970.

24. Cowan, P. A. and D. B. Porcella. Analytical Methods at UWRL. Unpublished. Utah State University, Logan, Utah. 1972.

25. Whipple, G. C. The Microscope of Drinking Water. John Wiley and Sons, Inc., N. Y. 1927.

26. Margalef, R. Perspectives in Ecological Theory. Univ. of Chicago Press, 109 p. 1968.

27. Margalef, R. Correspondence Between the Classic Types of Lakes and the Structural and Dynamic Properties of Their Populations. Verh. Intern. Verein. Limnol., 15:169-175. 1964.

28. Gonzales, J. Personal Communication. South Tahoe Public Utilities District, South Lake Tahoe, Calif. 1974.

29. Wickwire, Russ. Personal Communication and Unpublished Data. California Fish and Game Department, Tahoe City, Calif. 1974.

30. Skarheim, H. P., T. R. Galloway, R. E. Selleck, A. J. Horne and W. J. Kaufman. Assessment of Biological Effects of Treated Wastewater on the Truckee River. SERL Rept. No. 73-2, Univ. of Calif., Berkeley, 129 p. 1973.

31. Stumm, W and J. J. Morgan. Aquatic Chemistry. Wiley Interscience, N. Y., p. 241. 1970.

32. Horne, A. J. and C. R. Goldman. Nitrogen Fixation in Clear Lake, Calif. I. Seasonal Variation and the Role of Heterocysts. Limnol. and Oceanogr., 17:678-692. 1972.

33. Whitton, B. A. Freshwater Plankton. In: The Biology of Blue-Green Algae (Carr and Whitton, Eds.). Botanical Monogr. 9, Univ. of Calif. Press, Berkeley. 1973.

SECTION VIII

PUBLICATIONS AND PATENTS

No patents were produced in the course of the project. Three publications were released by the Lake Tahoe Area Council pursuant to the terms of the initial grant. These are:

1. Eutrophication of Surface Waters--Indian Creek Reservoir. First Progress Report (FWQA Grant No. 16010 DNY). Lake Tahoe Area Council, South Lake Tahoe, Calif. 141 p. May 1970.

2. Eutrophication of Surface Waters--Lake Tahoe: Indian Creek Reservoir. EPA - 16010 DNY 07/71. 115 p. July 1971.

3. Response to Tertiary Effluent in Indian Creek Reservoir. Journal WPCF, 44:2148-2161. 1972.

SECTION IX

GLOSSARY

The following list represents the sense or context in which various terms and symbols are used in this report, without specific regard to generalized or standard definitions.

Benthic Sludge - Accumulated organic and organic sediment on the bottom of the reservoir.

Benthic Invertebrates - Invertebrate organisms living in or upon the benthic sludge.

Bioassay - Laboratory measurements of the effect of nutrients or other factors on the rate of growth of a test alga under specified conditions.

Biostimulation - Increase in the expected or normal response of an organism as a result of the presence of some growth stimulating factor.

Conservative Element - Chemical element not significantly removed or increased by chemical, physical, or biological processes.

Denitrification - Reduction of nitrate or nitrite to nitrogen gas by aerobic bacteria living under anaerobic conditions.

Discharged, or Released, Water - Water purposefully released from Indian Creek Reservoir for irrigation use.

Eutrophic - Nutrient rich condition of water.

Grazers - Aquatic animals which eat plant material, e.g., herbivorous zooplankton such as Daphnia.

Hypolimnion - Region below the thermocline in a body of water.

Impounded Water - Mixture of influent reclaimed water and surface runoff plus precipitation stored in Indian Creek Reservoir.

Infiltration - Movement of water downward into the soil through the soil-water interface, or bottom, of the reservoir.

Influent Reclaimed Water - Domestic sewage effluent exported to Indian Creek Reservoir after advanced treatment at the South Tahoe Public Utility District's reclamation plant.

Limnology - The study of physical, chemical, biological, and environmental interrelationships in fresh water, particularly lakes and ponds.

Mechanical Aeration - Bubbling or air through the impounded water with the purpose of saturating it with oxygen in equilibrium with the atmosphere.

Mixing - The intermingling of water masses in Indian Creek Reservoir so that passive materials such as chemical constituents are uniformly distributed horizontally and vertically when the reservoir is well mixed.

Nitrification - Oxidation of ammonia to nitrate or nitrite by specific bacteria, called nitrifiers.

Nutrient Budget - The algebraic sum of the effect of all factors which add or subtract a specific plant nutrient, such as nitrogen or phosphorus, in the reservoir, i.e., an accounting for all inputs and outputs of a particular nutrient.

Nutrient Recycling - Movement of nutrients through the natural cycle of growth and decay of organic matter.

Oligotrophic - Nutrient poor condition of water.

Plankton - The host of free living microscopic plants (phytoplankton) and animals (zooplankton) in water.

Productivity - The rate of change of biomass with time in a system, expressed in amount per unit area or unit volume, e.g., lbs fish per acre per year.

Secchi Disc - An 8-inch diameter white disc used to measure the clarity of water in terms of depth below the water surface at which it disappears from sight of the observer.

Seiche - An oscillating wave motion in the reservoir caused by winds.

Toxicity - The presence of factors which decrease or inhibit the expected or normal response of an organism.

$\underline{\hat{\mu}_b}$ - Maximum rate of increase in algal cell numbers or mass during a 5-day flask bioassay.

$\underline{X}$ - Algal cell counts performed at days 1, 3, 5.

$\underline{SS_5}$ - Dry weight of suspended solids in flask at end of 5-day bioassay.

SECTION X

APPENDICES

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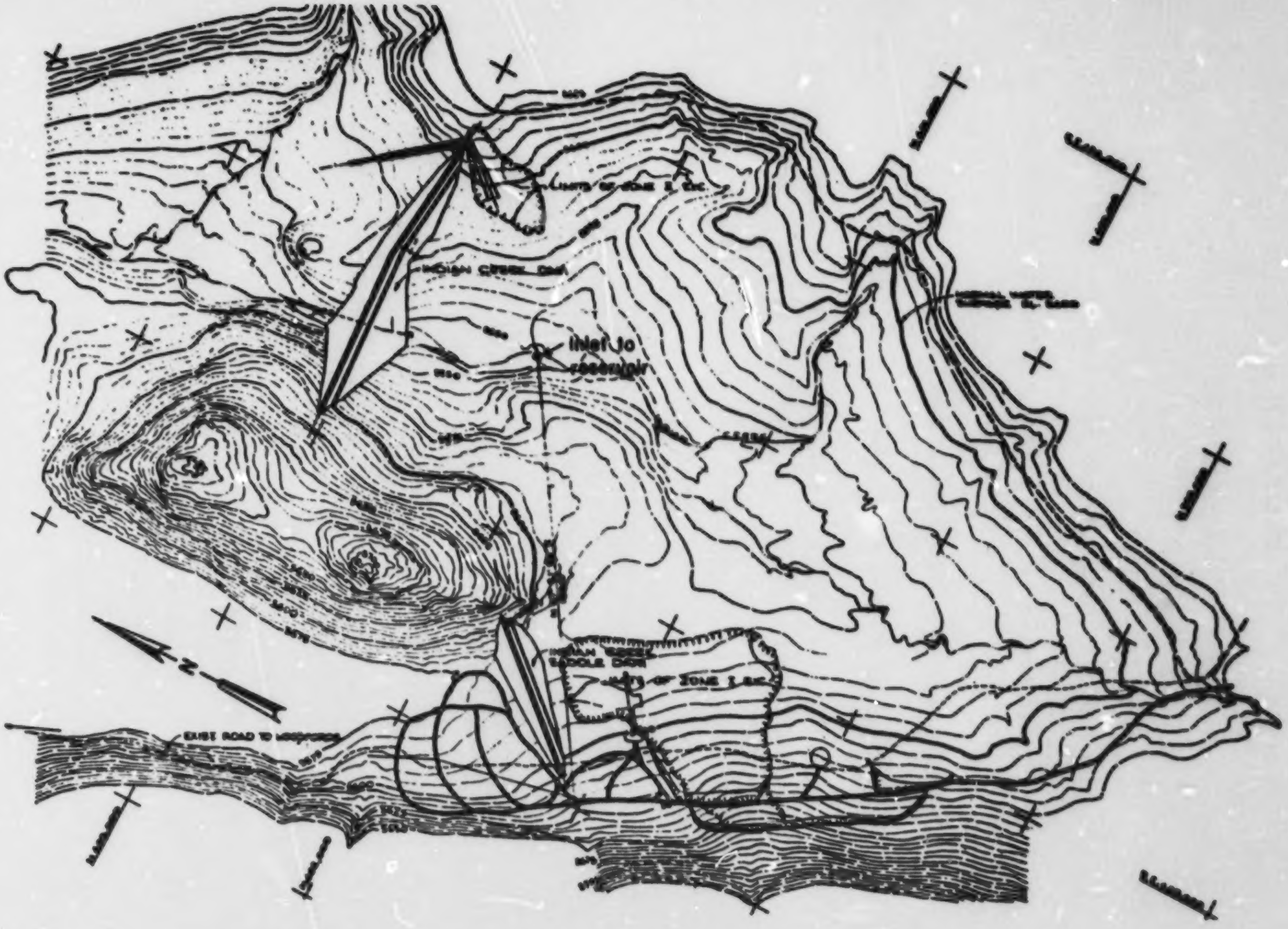

LIMITS OF ZONE 2 EXC.
INDIAN CREEK DAM
Inlet to reservoir
INDIAN CREEK SADDLE DAM
LIMITS OF ZONE 1 EXC.
EAST ROAD TO
N

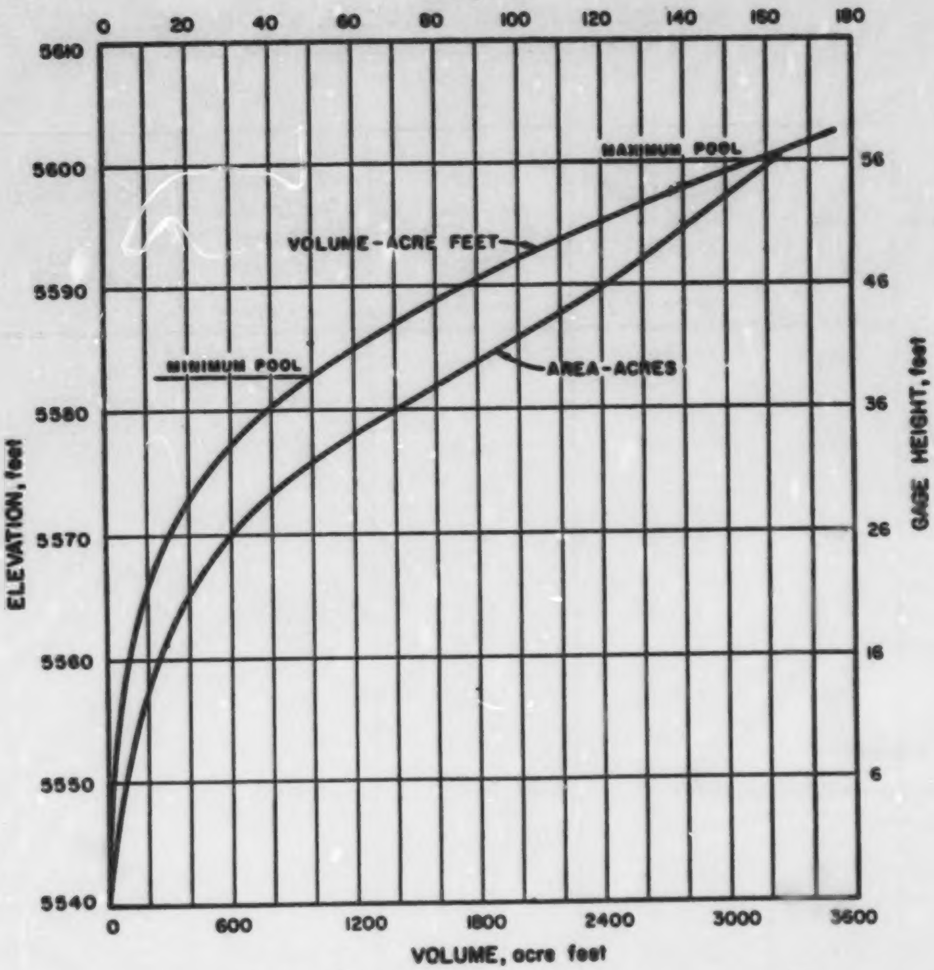
APPENDIX I. CONTOUR MAP OF INDIAN CREEK RESERVOIR (2)

APPENDIX 2

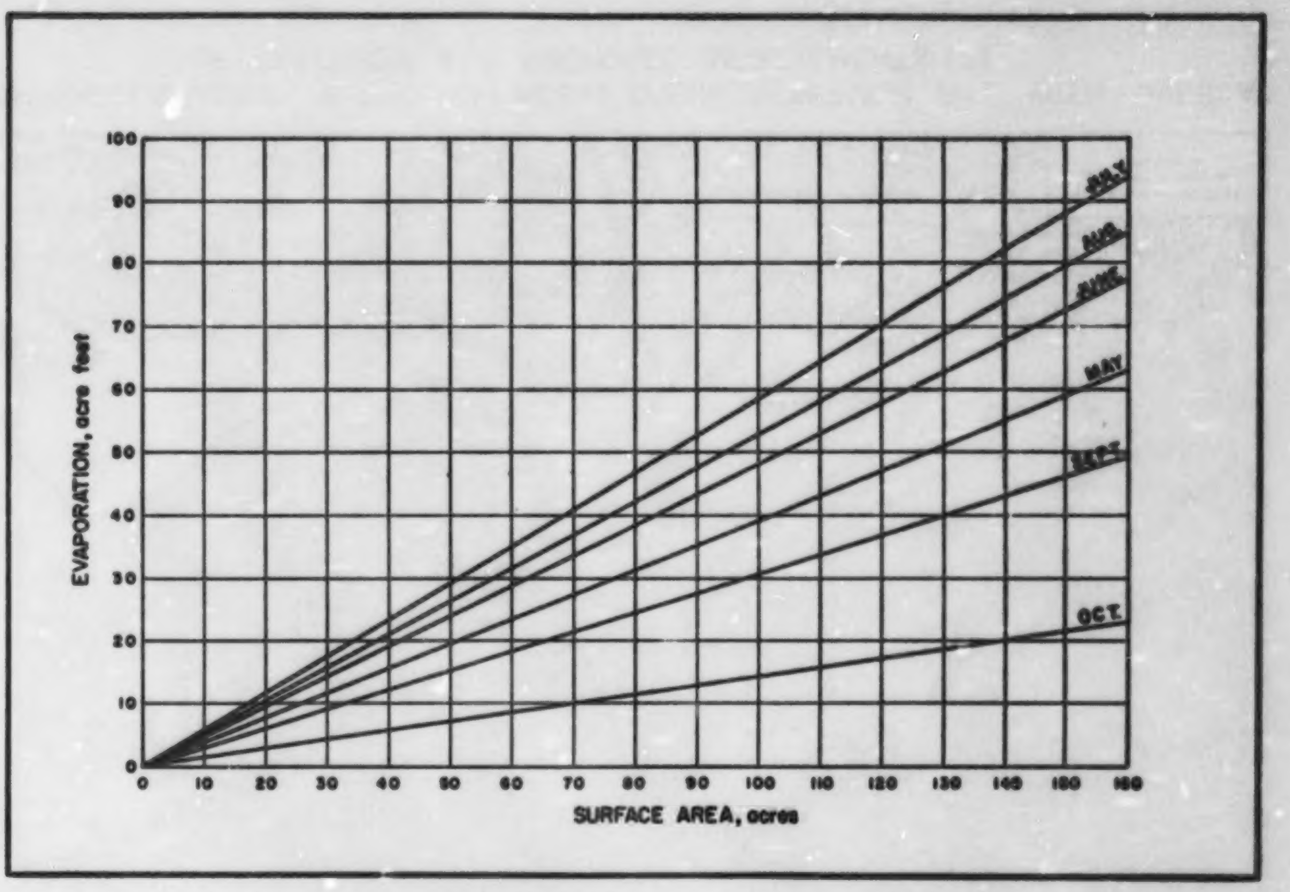
RECLAIMED WATER AS PERCENTAGE OF INPUT TO INDIAN CREEK RESERVOIR (ESTIMATED)

Year	Reclaimed Water Inflow (acre-ft)	Runoff Inflow From 1700 Acres (acre-ft)	Percent Reclaimed Water Annual (%)	Percent[a] Reclaimed Water Maximum 3-Months (%)
1970	3,684	815	72.0	99
1975	4,912	815	86.0	99.3
1980	6,140	815	88.0	99.5
1985	7,368	815	90.0	99.5
1990	8,596	815	91.5	99.5
1995	10,131	815	92.5	99.7
2000	11,666	815	93.5	99.7 +
2005	12,894	815	94.0	99.8 -
2010	13,815	815	94.0	99.8 -
2015	14,122	815	94.5	99.8 -
2018	14,276	815	94.5	99.8

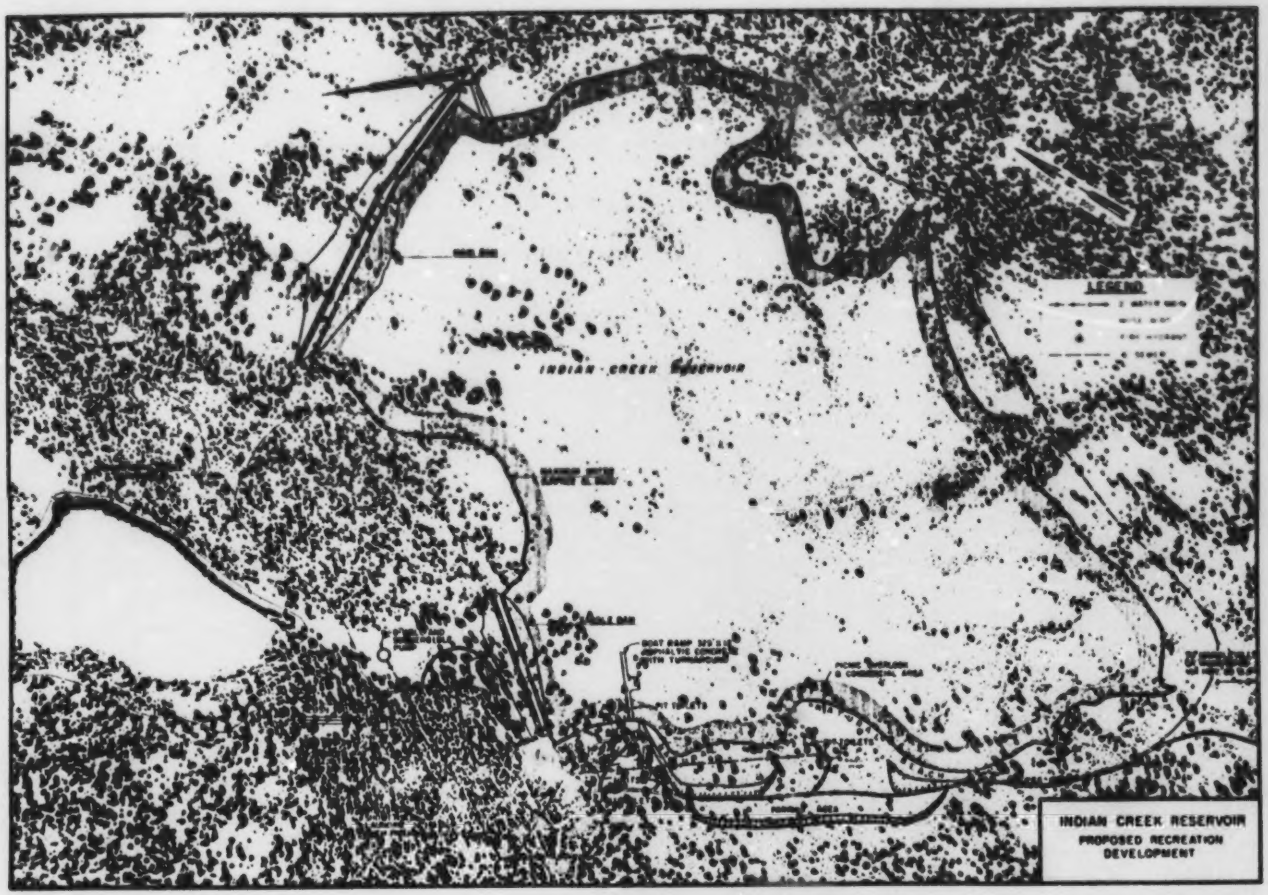
[a] Computed from data [2] not shown in this table.



APPENDIX 3. INDIAN CREEK RESERVOIR AREA AND CAPACITY (2)



APPENDIX 4. INDIAN CREEK RESERVOIR EVAPORATION BY MONTH IN ACRE FEET (2)


INDIAN CREEK RESERVOIR
LEGEND
INDIAN CREEK RESERVOIR
PROPOSED RECREATION
DEVELOPMENT

APPENDIX 5. AERIAL PHOTO OF INDIAN CREEK RESERVOIR SITE WITH OVERLAY OF RESERVOIR AND PROPOSED IMPROVEMENTS (2)

APPENDIX 6

MEASURED WATER INPUTS AND WITHDRAWALS, INDIAN CREEK RESERVOIR (15)

Month 1971	Monthly Reclaimed Water Inflow $10^3 M^3$	(Acre feet)	Withdrawn for Irrigation $10^3 M^3$	(Acre feet)	Runoff Factors (from 2)
April	104	(84.5)	10	(8.0)	
May	101	(82.1)	70	(57.0)	
June	102	(82.6)	-		
July	121	(98.4)	-		
August	129	(104.5)	212	(172.1)	
September	103	(83.9)	138	(111.8)	
October	89	(71.8)	-		
November	84	(67.7)	25	(20.0)	
December	95	(77.1)	38	(310.0)	
1972					
January	94	(75.9)	123	(100.0)	0.4
February	95	(76.7)	-		0.4
March	98	(79.8)	-		0.4
April	95	(76.9)	-		0.3
May	97	(78.8)	-		0.1
June	100	(81.0)	-		0.1
July	126	(102.4)	179	(145.0)	0.1
August	136	(110.0)	344	(279.0)	0.1
September	106	(86.1)	100	(81.0)	0.1
October	97	(78.3)	-		0.1
November	89	(71.94)	-		0.1
December	113	(91.6)	-		0.3

APPENDIX 6 (continued). MEASURED WATER INPUTS AND WITHDRAWALS, INDIAN CREEK RESERVOIR (15)

Month	Monthly Reclaimed Water Inflow $10^3 M^3$	(Acre feet)	Withdrawn for Irrigation $10^3 M^3$	(Acre feet)	Runoff Factors (from 2)
1973					
January	118	(95.9)	-		
February	99	(80.5)	-		
March	105	(85.0)	-		
April	110	(89.5)	-		
May	110	(89.1)	75	(61.0)	
June	115	(93.5)	115	(93.5)	
July	138	(112.2)	395	(320.1)	
August	145	(117.8)	459	(372.0)	
September	134	(108.9)	252	(204.0)	
October	98	(79.4)	-		
November	101	(82.0)	-		
December	109	(88.3)	-		
1974					
January	153	(124.2)	-		
February	107	(86.9)	-		
March	128	(104.0)	-		
April	130	(105.6)	78	(63.0)	

APPENDIX 7

MODIFIED SKULBERG NUTRIENT MEDIUM (1967)

Macronutrients	Final Concentration (mg/l)	Micronutrients (Adopted from Myers, 1951)*	Final Concentration (mg/l)
$NaNO_3$	46.7	$CO(NO_3)_2 \cdot 6H_2O$	0.0012
$Ca(NO_3)2 \cdot 4H_2O$	5.9	$(NH_4)_6\ MO_7O_{24} \cdot 4H_2O$	0.0122
K_2HPO_4	3.1	$CuSO_4 \cdot 5H_2)$	0.0200
$MgSO_4 \cdot 7H_2O$	2.5	$Zn(C_2H_3O_2)$	0.0382
Na_2CO_3	2.1	$MnCl_2 \cdot 4H_2O$	0.050
Fe EDTA ($FeSO_4$ + Na_2 EDTA)	0.2 as Fe	H_3BO_3	0.50

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*Myers, J. (1951). "Physiology of the Algae," Ann. Rev. Microbiology, 6:165-180.

APPENDIX 8

ANALYSES - INDIAN CREEK RESERVOIR

Date	Sample Type	Res. Depth	Secchi Disk	Temperature		Unfiltered Samples					0.45 µ Millipore Filtered Samples											
											Nitrogen as N				Phosphorus as P		Ca	Cl⁻	Fe	pH	Alk. as $CaCO_3$	Cond. (10^{-6})
				Water	Air	Susp. Solids	Vol. Susp. Solids	COD	DO	Inorg. C	Org.	NH_3	$NO_2 + NO_3$	Total	PO_4	Total						
		ft	ft	°C	°C	mg/l	mg/l	mg/l	mg/l	mg/l	µg/l	µg/l	µg/l	µg/l	µg/l	µg/l	mg/l	mg/l	µg/l		mg/l	mhos
1971 6/2	C	53.1	12.0	13.5	11.0	2.78	1.42	14.8	7.4	40.9	1055	5572	1942	8569	11	148	48.1	26.70		7.9	167.1	464
	III					1.70	0.82	13.3	1.0	58.1	368	12540	182	13096	99	142	59.1	26.91		7.8	237.8	572
	0.5 m			13.5					7.4	40.9								26.57		8.0	167.1	512
	3.5 m			12.9					6.3	40.7								26.50		8.0	166.1	495
	6.5 m			12.6					6.4	41.2								26.70		8.0	168.1	490
	9.5 m			12.5					6.0	40.7								26.29		8.0	166.1	490
6/14	C	53.1	7.8	18.0		3.39	2.34	16.4	9.3	39.2	1165	5187	2200	8552	7	32	47.2	25.79		8.2	159.9	440
	III					0.94		6.6	3.6	58.3	317	19939	268	20524	307	349	54.0	25.65		7.6	237.8	616
	0.5 m			18.0					9.3	40.4								27.29		8.3	168.0	430
	3.5 m			16.5					10.1	40.4								26.63		8.2	165.0	430
	6.5 m			15.1					6.8	41.2								26.77		8.0	168.1	451
	9.5 m			14.2					3.6	42.7								26.77		7.8	174.3	506
6/21	C	53.3	17.5	18.7	25.0	1.29	0.80	17.4	10.3	39.4	997	5200	1797	7994	4	28	48.2	29.54		8.2	160.9	460
	III					2.20	1.68	17.1		58.0	497	16460	96	17051	90	119	53.8	34.58		7.9	236.8	633
	0.5 m			18.7					10.3	39.7								28.46		8.2	161.9	483
	3.5 m			18.5					9.0	39.4								30.84		8.2	160.9	483
	6.5 m			16.8					5.4	40.9								31.56		8.2	167.1	495
	10.0 m			14.7					0.7	43.7								28.03		8.7	178.3	506
7/7	C	53.7	12.9	19.8	23.5	1.94	1.33	10.2	10.8	39.4	820	6505	4220	11545	13	53	47.8	28.78		8.0	160.9	550
	III					1.76	1.53	17.8	1.4	63.3	342	26900	365	27607	366	444	48.8	28.52		7.9	258.3	682
	0.5 m			19.8					10.8	39.7								27.83		8.1	162.0	533
	3.5 m			19.6					9.3	40.7								27.75		8.1	166.1	506
	6.5 m			19.0					6.7	41.2								28.95		8.1	168.1	506
	10.5 m			18.2					5.0	40.9								28.18		8.1	167.1	503
7/19	C	53.9	13.0	21.1	22.0	2.02	1.12		10.2	40.7	52	5615	2232	7899	24	41	45.8	29.38		8.1	166.1	488
	III					1.66	1.15		1.5	62.5	<1	17500	630	18130	446	478	49.6	31.54		8.1	255.2	668
	0.5 m			21.1					10.2									29.63				514
	3.5 m			21.0					11.8									30.56				509
	6.5 m			20.0					6.8									29.29				509
	10.0 m			19.2					4.2									27.78				514
7/26	C	53.9	17.0	22.0	21.0	1.24	0.81	12.2	6.9	40.2	794	4115	2746	7655	15	41	44.4	31.25	Resume Iron 8/2	8.2	164.0	466
	III					0.53	0.52	5.9	0.4	69.6	889	24280	904	26075	366	433	54.4	28.55		7.9	283.9	700
	0.5 m			22.0					6.9	40.9								30.32		8.2	167.1	498
	3.5 m			22.0					6.6	40.7								29.98		8.2	166.0	509
	6.5 m			21.0					5.6	41.4								30.66		8.2	169.1	511
	8.0 m			20.5					3.0	42.7								30.24		8.0	174.3	530
8/2	C	53.9	17.0	23.5	23.0	1.13	0.79	9.2	7.8	39.4	1181	5202	2978	9361	30	88	46.2	30.77	1	8.1	160.9	516
	III					3.51	1.45	7.7	1.4	71.8	533	24112	42	24687	27	143	59.0	28.80	<1	7.8	293.2	692
	0.5			23.5		1.17	0.88	1	7.8	39.9	994	4941	2920	8855	23	88	45.8	28.48	<1	8.0	163.0	494
	3.5			22.5		1.58	1.33		7.0	39.2	1051	6050	2848	9949	27	89	45.8	28.40	<1	8.0	159.9	493
	6.5			22.2		1.19	0.84		7.2	41.7	972	7811	2297	11080	74	167	45.8	28.64	<1	7.9	170.2	515
	10.5			20.4		1.02	0.13		1.5	43.5	781	6115	1884	8780	120	175	46.8	28.48	<1	7.9	177.3	515
8/9	C	53.9	10.0	23.5	29.3	1.14	0.93	11.6	7.1	38.7	452	5833	2848	9133	21	57	46.2	29.74	<1	8.2	157.8	504
	III					3.03	1.29	11.6	0.7	67.5	230	24374	187	24791	34	41	55.4	33.45	<1	8.0	275.7	688
	0.5			23.5					7.1	40.2								29.14		8.1	164.0	504
	3.5			22.1					7.6	39.4								28.97		8.1	160.9	504
	6.5			21.9					6.7	38.9								29.40		8.0	158.9	499
	8.5			21.8					4.6	40.7								29.14		8.2	166.1	506
8/16	C	53.6	9.2	21.0	20.0	1.27	0.76	11.3	7.7	38.9	852	4789	4039	9680	68	104	49.6	32.61	<1	8.1	158.9	520
	III					3.95	2.37	12.6	0.6	62.5	600	24287	1986	26873	494	529	50.6	35.71	<1	7.9	255.2	683
	0.5			21.0		2.44	1.34		7.7	40.4	948	6289	3460	10697	68	114	49.8	33.65	<1	8.1	166.0	504
	3.5					2.10	1.20		7.8	40.4	939	5398	3468	10105	70	89	49.8	33.27	<1	8.1	165.0	502
	6.5					1.77	1.12		7.3	40.2	1018	5833	3782	10633	64	90	49.6	33.55	<1	8.0	164.0	502
	8.5					2.25	1.14		6.7	39.4	983	5463	3681	10127	60	77	49.4	33.36	<1	8.1	160.9	504
8/23	C	52.9	12.5	21.0	24.0	1.29	0.78	11.1	7.8	38.7	1138	6050	4251	11439	68	92	50.4	29.63	1	8.0	157.9	507
	III					1.13	0.85	15.2	2.1	62.8	836	26020	4390	31248	231	264	58.6	34.09	16	7.8	256.3	700
	0.5			21.0					7.8	39.7								29.89		7.9	162.0	
	3.5			20.5					8.3	39.2								29.46		8.0	159.9	
	6.5			20.0					8.6	39.2								29.89		8.0	159.9	
	8.0			20.0					7.9	39.7								29.72		7.9	162.0	

APPENDIX 8. Continued

ANALYSES – INDIAN CREEK RESERVOIR

Date	Sample Type	Res. Depth	Secchi Disk	Temperature		Unfiltered Samples					0.45 µ Millipore Filtered Samples											
				Water	Air	Susp. Solids	Vol. Susp. Solids	COD	DO	Inorg. C	Nitrogen as N: Org.	NH3	$NO_2 + NO_3$	Total	Phosphorus as P: PO_4	Total	Ca	Cl^-	Fe	pH	Alk. as $CaCO_3$	Cond. (10^{-6})
		ft	ft	°C	°C	mg/l	mg/l	mg/l	mg/l	mg/l	µg/l	µg/l	µg/l	µg/l	µg/l	µg/l	mg/l	mg/l	µg/l		mg/l	mhos
8/30	C	52.9	12.1	20.0	22.1	1.56	0.82	13.7	8.4	40.4	1101	2985	3448	7534	75	85	48.6	32.34	3	8.2	146.0	501
	III					0.64	0.52	12.3	0.4	61.8	42	24287	42	24371	77	108	40.6	28.17	16	8.5	252.2	680
	0.5			20.0		1.82	1.36	13.7	8.4	37.7	1094	2985	3869	7948	54	80	47.4	30.97	13	8.1	153.0	491
	3.5			19.5		2.36	1.61	14.3	8.2	37.7	1050	[illegible]	4492	8787	60	80	48.2	30.55	14	8.2	153.0	512
	6.5			19.5		1.67	1.29	10.6	8.4	38.2	811	1876	4332	7019	61	92	48.4	30.55	10	8.2	155.0	512
	8.0			19.2		2.71	1.40	10.9	7.8	36.9	1211	2615	4609	8435	52	81	48.2	30.72	4	8.2	150.7	491
9/7	C	52.0	11.0	17.8	20.8	1.18	0.62	9.9	8.6	36.9	1000	5202	3913	10115	60	74	47.6	28.67	<1	8.0	150.7	518
	III					0.60	0.56	7.2	1.0	65.3	142	23418	5	23565	96	114	41.4	27.99	10	8.2	266.5	667
	0.5			17.8					8.6	37.4								28.67		8.2	152.7	502
	3.5			17.1					9.6	36.9								29.01		8.2	150.7	508
	6.5			17.0					10.6	36.9								28.84		8.1	150.7	508
9/14	C	51.5	13.2	19.0	22.1	1.04	0.79	11.5	11.3	36.4	789	3940	2016	6745	27	57	46.8	33.95	11	8.3	148.6	499
	III					0.41	0.25	11.2	0.8	65.1	350	13852	5	14207	77	90	36.8	33.16	8	8.3	265.5	662
	0.5			19.0		2.51	2.12	9.2	11.3	37.9	1263	2050	2064	5377	30	64	46.6	33.60	8	8.1	154.8	520
	3.5			18.0		1.17		11.9	11.8	36.8	1142	5158	5536	11836	41	67	46.8	33.78	7	8.1	150.2	515
	6.5			18.0		2.44	1.54	11.2	8.6	36.8	1311	2485	5145	8941	51	72	47.4	33.87	6	8.1	150.2	520
9/20	C	51.4	14.5	17.0	20.0	2.21	0.90	10.9	9.8	37.2	1215	5135	4319	10669	44	70	47.6	34.33	9	8.2	151.7	545
	III					6.49	2.00	11.9	1.0	62.8	876	15418	46	16340	85	98	53.4	33.27	10	8.2	256.3	596
	0.5			17.0		2.09	1.27	10.6	9.8	36.9	997	5094	5290	11381	43	61	46.8	33.89	3	8.3	150.7	545
	3.5			16.8		1.40	1.13	10.3	10.3	36.7	1031	5115	4913	11059	41	60	46.8	34.33	6	8.2	149.7	682
	6.5			16.8		2.23	1.29	11.3	9.8	36.2	867	4595	5188	10650	40	61	46.4	35.12	6	8.2	147.6	590
9/27	C	51.5	13.4	14.5	14.0	1.01	0.69	14.4	9.7	36.8	865	4115	5797	10777	49	247	49.4	34.23	5	8.0	150.0	522
	III					4.82	2.43	8.4	1.0	65.2	360	20374	301	20975	42	96	55.0	30.64	7	7.9	266.0	668
	0.5			14.5		1.30	1.14	11.4	9.7	36.5	813	4376	5638	10827	34	67	48.2	32.71	8	8.0	149.0	504
	3.5			14.0		1.46	1.27	15.4	10.3	36.0	691	5200	6203	12094	35	69	47.6	32.80	4	8.0	147.0	525
	6.5			13.9		1.70	1.35	11.4	10.8	35.3	605	3898	5623	10126	34	132	48.2	33.42	7	8.0	144.0	528
10/5	C	51.7	16.8	12.0	19.0	1.57	1.23	12.0	10.7	35.0	1263	4375	5200	10838	28	54	47.0	30.76	8	8.2	143.0	510
	III					6.78	2.65	7.3		64.9	137	18113	247	18497	15	32	57.6	28.13	13	8.1	265.0	666
	0.5			12.0					10.7	35.0								30.87		8.2	143.0	519
	3.5			11.8					12.9	35.0								31.14		8.2	143.0	514
	6.5			11.5					14.1	35.0								31.23		8.2	143.0	514
10/11	C	51.8	16.9	14.0	22.0	0.77		11.7	11.4	36.0	1081	3900	5348	10329	32	49	49.8	36.25	7	8.1	147.0	497
	III					4.26	1.77	4.9	0.6	65.2	295	17760	174	18229	14	29	59.8	31.75	12	7.9	266.0	650
	0.5			14.0		1.70	1.17	11.3	11.4	35.0	1090	4505	6320	11915	30	51	49.0	33.74	8	8.1	143.0	497
	3.5			13.0		2.21	1.69	16.8	11.3	35.5	1169	4660	4960	10789	29	51	48.2	34.00	13	8.1	145.0	513
	6.5			12.8		1.75	1.26	11.3	12.9	35.8	1134	4355	5840	11329	30	54	47.4	32.93	6	8.1	146.0	508
10/18	C	52.0	15.9	11.0	11.0	1.11	0.63	11.0	11.1	34.5	1060	3680	6594	11334	31	47	48.4	33.21	10	7.9	141.0	518
	III					4.52	1.86	8.6	0.2	62.0	60	20374	195	20629	8	12	55.8	31.61	1	7.8	253.0	637
	0.5			11.0		16.92	4.40	21.3	11.1	35.5	1068	3811	6348	11227	34	55	47.4	31.79	6	7.9	145.0	524
	3.5			10.8		3.40	1.83	9.6	13.4	34.8	1086	4311	6203	11600	35	46	47.0	31.61	13	8.0	142.0	540
	6.5			10.8		1.94	1.25	9.3	9.0	35.0	973	3463	6638	11074	37	44	47.2	32.05	10	8.0	143.0	524
10/27	C	Grab Sample				6.09	1.77	15.4		36.0	1190	4583	6507	12280	54	141	49.2	31.62	3	8.0	147.0	512
	III					5.00	1.91	18.6		69.1	521	36330	214	27065			72.0	59.74	3	7.9	282.0	765
11/1	C	52.1	19.0	7.0	17.0	1.21	0.63	13.8	9.4	34.8	1257	5533	8522	15312	40	61	45.4	35.79	14	8.0	142.0	596
	III					2.08	1.14	11.6	0.6	58.6	527	24230	783	25540	158	185	66.8	62.32	16	7.9	239.0	765
	0.5			7.0		5.91	1.72	17.8	9.4	36.5	1357	6583	6261	14201	51	71	45.6	35.97	15	8.0	149.0	594
	3.5			6.5		4.12	2.11	17.8	10.1	35.3	1407	5808	6896	14111	40	59	47.8	35.43	10	8.1	144.0	578
	6.5			6.2		2.92	1.57	14.1	11.5	35.5	1397	5808	6204	13409	40	57	49.6	34.62	12	8.1	145.0	574
11/8	C	52.3	17.8	6.8	12.0	1.69	0.74	12.5	9.8	36.0	1100	5158	5436	11694	47	58	50.6	35.89	8	8.0	147.0	890
	III					2.49	1.78	13.8	1.4	53.9	485	29530	757	30772	122	132	72.8	72.77	8	7.7	220.0	933
	0.5			6.8		25.99	5.56	15.3	9.8	36.3	1480	6958	6768	15206	45	61	51.2	28.63	8	8.0	148.0	742
	3.5			6.2		4.59	1.88	12.8	11.2	36.0	1185	5433	6680	13298	44	60	51.6	34.24	14	8.0	147.0	793
	6.5			6.0		3.86	1.64	16.5	12.3	35.5	1555	6288	7088	14931	45	58	50.6	34.08	28	7.9	145.0	917
11/15	C	52.8	14.0	5.0	2.0	1.33	0.67	13.4	10.2		1338	4783	5116	11237	39	62	50.6	36.67	27			451
	III					2.39	1.74	10.6	0.6		512	33330	562	34404	99	131	60.4	45.05	5			476
	0.5			5.0		2.95	1.34	10.6	10.2		1157	5708	5840	12705	29	40	50.4	34.63	23			
	3.5			5.0		2.68	1.36	13.4			1362	5033	5652	12047	39	60	49.8	34.61	18			
	6.5			5.0		4.38	1.58	13.7	11.0		1522	5933	6436	13891	43	64	49.6	34.30	43			

APPENDIX 8. Continued

ANALYSES – INDIAN CREEK RESERVOIR

Date	Sample Type	Res. Depth	Secchi Disk	Temperature		Unfiltered Samples					0.45 μ Millipore Filtered Samples											
				Water	Air	Susp. Solids	Vol. Susp. Solids	COD	DO	Inorg. C	Nitrogen as N				Phosphorus as P		Ca	Cl^-	Fe	pH	Alk. as $CaCO_3$	Cond. (10^{-6})
											Org.	NH_3	$NO_2 + NO_3$	Total	PO_4	Total						
		ft	ft	°C	°C	mg/ℓ	mg/ℓ	mg/ℓ	mg/ℓ	mg/ℓ	μg/ℓ	μg/ℓ	μg/ℓ	μg/ℓ	μg/ℓ	μg/ℓ	mg/ℓ	mg/ℓ	μg/ℓ		mg/ℓ	mhos
11/22	C	52.9	17.5	4.0	13.0	1.13	0.63	12.8	10.8	36.3	1527	4858	6636	13021	53	65	50.2	40.05	13	7.9	168.0	559
	III					1.77	1.47	11.0	0.6	63.0	767	23430	741	24938	203	225	58.2	32.22	13	7.7	237.0	672
	0.5			4.0		7.31	3.84	20.7	10.8	36.5	997	7382	7000	15379	60	79	50.6	37.99	10	8.0	169.0	516
	3.5			4.0		15.08	2.48	10.7	11.4	36.5	1177	6333	6636	16146	79	101	49.4	37.41	8	7.9	169.0	523
	6.5			4.0		3.11	1.63	11.9	10.6	36.0	1187	6783	7796	15766	51	69	48.8	37.76	8	7.8	167.0	525
11/30	C	53.0	17.9	4.0	3.5	1.11	0.55	11.8	10.5	35.3	1514	6333	7944	15791	52	68	48.6	39.06	9	7.9	166.0	582
	III					1.53	1.20	10.0	0.6	58.1	734	36830	415	37979	95	107	53.8	29.86	4	7.7	237.0	638
	0.5			4.0		3.69	1.35	10.3	10.5	35.5	1439	6158	7388	14985	47	68	48.8	37.33	8	8.0	165.0	560
	3.5			4.0		5.68	1.96	9.7	10.6	36.3	1469	5133	7580	14382	46	62	48.4	38.02	12	8.0	168.0	558
	6.5			4.0		4.14	1.94	16.8	10.8	36.0	1389	6783			46	70	48.6	36.87	16	8.0	167.0	560
1972 1/10	C	Frozen		2.9	9.0	4.09	1.22	11.0	9.8	31.4	1416	6583	10120	11119	80	101	45.4	40.36	14	8.0	128.0	526
	III					2.66	1.83	17.5	0.7	55.9	486	22320	610	23426	428	462	53.0	35.07	6	7.9	228.0	681
	0.5			2.9		2.00	1.18	11.7	9.8	32.8	1321	9458	7280	17979	95	106	40.2	37.18	10	8.0	136.0	526
	3.5			3.0		2.25	1.02	11.0	9.0	31.9	1361	8883	4640	14886	101	114	48.6	37.76	10	8.0	130.0	526
	6.5			3.2		3.68	1.29	13.8	9.8	34.5	1321	10833	5720	17874	121	132	40.6	36.98	8	8.0	141.0	550
1/24	C	Frozen		3.5	8.2	3.81	1.37	7.3		40.4		7133	4880		118	126	54.0	36.82	38	8.0	165.0	569
	III					1.36	0.99	7.9		63.7		25330	170		350	385	66.0	31.00	48	8.1	360.0	672
	0.5			3.5		1.80	0.98	10.6		43.6		11208	6316		118	147	58.2	36.91	34	8.0	170.0	605
	3.5			3.2		1.67	0.92	7.9		41.6		9708	5040		98	133	55.4	35.09	40	8.0	170.0	564
	6.5			2.8		1.64	0.92	6.7		41.9		11208	6044		114	135	56.0	36.00	34	8.0	171.0	571
3/27	C	51.0	3.7	9.0	1.0	4.86	4.08	16.0	11.6	40.9	1152	7175	3908	12235	9	25	57.2	38.97	7	8.3	167.0	510
	III					2.65	1.49	11.6		53.7	981	21840	3866	26667	132	154	68.4	27.47	18	8.0	219.0	769
	0.5			9.0		6.19	5.35		11.6	39.2	2015	7086	4446	13566	11	30			10	8.1	180.0	494
	3.5			8.8		4.02	3.40		10.0	38.5	1101	8230	3677	13008	12	33			12	8.3	157.0	478
	6.5			8.2		3.36	2.72		9.8	38.5	929	10115	3846	14890	12	29			13	8.3	157.0	492
4/3	C	51.1	4.1	10.0	15.0	5.38		17.2	13.0	37.2	1178	6890	4152	12220	8	44	52.7	33.10	15	8.0	152.0	519
	III					3.11	2.16	13.2	0.6	53.9	1509	16696	3624	21829	71	89	77.9	29.95	3	8.0	228.0	684
	0.5			10.0		7.12	6.49	28.0	13.0	38.7	1235	7630	4768	13633	8	26	53.6	32.61	18	8.1	158.0	523
	3.5			9.2		7.90	7.36	32.0	12.1	37.7	1350	7888	5540	14778	13	32	54.8	33.20	18	8.1	154.0	513
	6.5			8.9		7.73	7.07	23.2	12.3	38.2	1190	8203	5540	14933	11	20	54.8	32.51	14	8.1	156.0	513
4/10	C	51.3		9.0	14.0	5.83	1.10	15.0	9.0	37.5	1360	6000	7640	15000	4	22	54.4	35.97	6	7.7	153.0	510
	III					2.56	1.61	8.5	0.6	59.8	1252	17268	325	18845	59	74	81.4	30.76	<1	7.6	246.0	676
4/17	C	51.5	16.0	9.0	9.5	1.17	0.65	13.4	7.3	37.5	1085	6289	1944	9318	18	33	54.5	33.51	17	8.1	153.0	528
	III					1.47	0.94	6.9		55.6	1805	14640	1809	18254	86	99	80.7	29.30	<1	7.8	227.0	622
	0.5			9.0		2.04	1.19	15.0	7.3	38.0	1657	7631	1596	10886	24	41	58.4	33.16	7	8.1	155.0	524
	3.5			9.0		3.35	2.61	16.3	8.3	37.5	1368	8232	1652	11232	24	38	55.3	33.33	11	8.1	153.0	523
	6.5			8.4		2.54	1.43	14.6	7.6	39.0	1309	6917	1580	9805	21	38	54.8	32.81	7	8.0	159.0	526
	9.5			8.1		3.24	2.25	17.5		37.2	1292	8146	1652	11090	23	39	54.8	32.02	20	8.0	152.0	526
4/25	C	52.0	20.0	10.5	13.0	1.32	0.63	11.2	7.6	36.7	1096	6600	6112	13808	35	52	55.6	35.28	11	8.2	150.0	552
	III					3.22	2.25	10.8	1.1	54.9	1393	14410	3682	19485	73	84	81.2	28.49	<1	7.8	226.0	684
	0.5			10.5		1.94	1.17	15.2	7.6	37.5	1393	7889	6600	15882	30	51	56.2	33.48	11	8.1	153.0	530
	3.5			9.6		2.90	1.89	14.8	7.2	37.0	1273	8115	6264	15652	33	48	55.8	33.30	7	8.2	151.0	528
	6.5			9.4		3.36	2.06	11.6	6.8	37.0	1782	6660	8200	16642	26	54	55.0	32.74	12	8.2	151.0	527
	9.5			9.0		7.25	3.57	18.0	5.3	37.0	1525	7775	7364	16664	40	172	55.0	32.74	8	8.1	151.0	528
5/1	C	52.1	19.9	11.2	17.0	1.07	0.69	12.0	7.6	36.5	962	5289	6400	12631	41	42	56.4	33.93	6	8.2	149.0	513
	III					2.56	1.88	9.2	0.6	45.6	1276	11440	6320	19036	172	78	66.0	32.24	12	8.0	186.0	560
	0.5			11.2		1.44	1.11	16.4	7.6	36.7	1277	6660	6252	14189	43	57	55.6	34.23	8	8.2	150.0	515
	3.5			11.0		3.30	1.96	13.2	7.5	36.7	1205	7376	7368	15947	43	66	55.0	33.83	<1	8.2	150.0	515
	6.5			10.9		2.34	1.45	13.2	6.5	37.0	1277	6003	6672	13952	46	66	55.0	34.13	9	8.1	151.0	515
	9.0			10.9		2.85	1.74	14.0	6.2	36.5	1594	7230	6672	15496	50	65	54.3	33.83	4	8.1	149.0	504
5/8	C	52.1	14.9	12.8	15.0	3.23	0.80	15.0	7.8	33.3	1516	4765	9712	15973	43	63	57.9	32.16	10	8.2	136.0	510
	III					3.43	1.19	9.7	1.4	38.5	1362	7660	11608	26638	86	104	67.6	32.71	<1	7.8	157.0	539
	0.5			12.8				16.2	7.8													543
	3.5			12.8		1.34	1.41	13.8	8.6	31.0	1928	5315	8296	15139	36	60	52.0	31.69	3	8.2	130.0	502
	6.5			12.5		1.16	1.72	17.8	9.0	31.1	1596	5174	8328	15098	43	68	51.4	31.78	10	8.2	127.0	494

APPENDIX 8. Continued

ANALYSES – INDIAN CREEK RESERVOIR

				Temperature		Unfiltered Samples					0.45 µ Millipore Filtered Samples												
											Nitrogen as N				Phosphorus as P								
Date	Sample Type	Res. Depth ft	Secchi Disk ft	Water °C	Air °C	Susp. Solids mg/l	Vol. Susp. Solids mg/l	COD mg/l	DO mg/l	Inorg. C mg/l	Org. µg/l	NH_3 µg/l	$NO_2 + NO_3$ µg/l	Total µg/l	PO_4 µg/l	Total µg/l	Ca mg/l	Cl^- mg/l	Fe µg/l	pH	Alk. as $CaCO_3$ mg/l	Cond. µmhos
5/15	C	52.1	9.0	15.5	22.0	4.66			11.4	35.5	1162	4765	6880	12807	13	29	54.0	38.23	4	8.3	165.0	515
	III					2.77	1.92	12.6	1.0	45.6	1266	13268	4100	18634	132	139	61.4	33.75	14	7.9	186.0	566
	0.5			15.5		4.30	3.79	19.6	11.4	35.5	1671	6174	7020	14865	21	43	55.0	35.12	4	8.3	165.0	519
	3.5			15.0		5.61	4.73	19.2	12.9	39.8	1677	5090	5590	12357	18	37	55.7	35.12	5	8.3	166.0	521
	6.5			13.5		2.32	2.16	15.6	9.2	37.0	1603	4860	7860	14323	54	73	56.4	34.73	5	8.1	151.0	517
	9.5			13.0		3.17	1.94	14.0	6.2	37.2	1471	5830	7610	14911	68	85	56.4	34.73	3	8.1	152.0	526
5/22	C	52.2	9.8	14.2	15.0	3.63	3.13	17.1	11.5	35.5	1605	3717	9707	15029	6	19	55.9	34.51	4	8.2	165.0	504
	III					3.91	2.50	14.1	2.0	48.0	1994	11554	5185	18733	128	140	67.8	32.67	<1	7.7	196.0	582
	0.5			14.2		3.55	3.38	15.6	11.5	35.8	1223	4831	9740	15794	9	24	56.9	33.81	1	8.3	166.0	506
	3.5			13.0		5.00	4.56	22.0	11.9	36.0	1497	5000	9460	15957	6	20	55.2	33.81	1	8.2	167.0	498
	6.5			13.5		4.33	3.86	16.7	10.9	35.8	1588	4974	9320	15882	11	27	56.9	33.98	1	8.3	166.0	501
	9.5			13.0		3.94	3.25	17.5	10.2	35.8	1434	5135	9390	15959	14	27	56.6	34.19	<1	8.3	166.0	498
5/30	C	52.4	21.7	19.0	25.0	1.19	0.68	17.7	10.1	36.3	745	2366	9770	12881	4	48	53.1	38.05	<1	8.5	160.0	504
	III					1.99	1.29	12.8	1.4	55.1	1385	22400	3510	27295	105	138	61.7	30.75	<1	8.1	225.0	590
	0.5			19.0		1.50	1.13	18.8	10.1	35.0	1334	4517	9460	15311	4	30	56.5	34.22	<1	8.5	163.0	510
	3.5			18.0		1.88	1.72	15.8	10.6	35.0	1334	4574	10400	16308	4	32	53.6	34.12	<1	8.5	163.0	510
	6.5			15.0		1.86	1.66	15.4	9.2	36.3	1385	4803	9394	15582	8	39	55.5	33.96	<1	8.4	168.0	490
	9.5			14.0		1.21	1.08	15.4	6.4	36.7	1603	6145	10550	18298	18	53	56.0	33.76	<1	8.3	190.0	508
6/5	C	52.4	18.0	19.0	21.0	1.02	0.82	17.5	8.9	33.8	1432	5280	13900	20612	3	29	51.9	34.08	12	8.4	138.0	493
	III					1.40	1.30	7.1	0.4	51.4	2015	11289	9850	21154	129	166	67.4	27.07	8	7.9	210.0	582
	0.5			19.0		1.13	1.19	10.0	8.9	33.6	1426	6980	8696	17102	5	23	53.1	32.10	7	8.4	137.0	479
	3.5			18.2		1.29	1.26	17.9	8.9	33.8	1926	6640	7825	16391	5	26	52.1	31.56	9	8.3	138.0	468
	6.5			16.3		1.36	1.14	10.0	5.0	36.7	1796	6980	7268	16044	75	97	54.8	31.38	11	8.2	190.0	498
	9.5			14.5				6.7	2.5	37.7	1244	7896	7059	16199	68	98	56.0	30.06	9	8.1	154.0	493
6/12	C	52.5	15.8	16.0	22.0	1.09	0.80	15.2	5.3	34.3	1132	2750	8200	12082	16	30	52.8	34.46	16	8.5	160.0	513
	III					1.24	1.19	7.4	0.6	53.2	989	9634	6685	17308	73	148	66.3	27.77	8	8.1	217.0	583
	0.5			16.0		4.14	1.01	12.6	5.3	35.5	1406	3666	8130	13202	38	61	52.9	33.01	18	8.4	145.0	499
	3.5			16.8		1.52	1.36	12.6	7.0	36.3	1246	4460	8550	14256	24	63	52.9	33.30	8	8.4	160.0	497
	6.5			16.5		1.81	1.68	18.5	8.1	36.5	1505	3831	9350	14686	17	35	52.8	33.40	6	8.4	161.0	497
	9.5			17.0		1.76	1.21	12.2	7.8	36.8	1406	4460	9670	15536	19	39	53.1	33.11	12	8.3	162.0	502
6/19	C	52.5	16.4	19.2	22.0	0.98	0.85	11.0	11.4	32.6	1109	2860	12460	16429	4	18	50.5	35.73	7	8.4	133.0	534
	III					0.75	0.73	4.4	1.0	53.2	1564	13580	4365	19509	104	125	65.5	28.48	4	7.9	217.0	580
	0.5			19.2		1.36		13.2	10.4	33.3	1355	3375	7930	12660	6	19	50.9	33.72	8	8.3	136.0	509
	3.5			18.8		2.28		13.2	11.8	32.6	1452	3375	8030	12857	4	21	50.9	33.81	19	8.3	133.0	536
	6.5			18.0		1.23	1.16	16.0	7.8	33.8	1367	3145	7930	12442	16	38	52.4	33.81	11	8.2	138.0	510
	9.5			16.2		1.69	1.11	13.2	3.8	37.0	1424	4974	6990	13388	83	99	56.9	33.14	13	8.2	151.0	522
6/26	C	52.5	24.0	19.2	24.0	1.20	0.75	14.6	9.5	29.4	1188	2844	60990	65022	12	26	48.4	34.00	5	8.0	120.0	429
	III					0.60	0.53	9.1	0.5	26.1	1296	19554	32700	53550	60	89	64.5	29.26	<1	7.7	229.0	575
	0.5			19.2		1.72	1.66	13.9	9.5	32.1	1325	4031	64350	69706	12	33	48.4	33.71	20	8.1	131.0	489
	3.5			19.0		2.00	0.89	15.3	9.0	31.6	1130	4317	63315	68762	12	29	47.9	34.67	15	8.0	129.0	480
	6.5			18.7		2.23	1.55	11.7	7.6	32.8	1279	5030	69570	75879	21	45	49.7	34.09	11	8.1	136.0	486
	9.5			17.8		2.37	1.61	11.7	4.8	36.3	1125	4232	67470	72827	79	104	52.6	33.62	211	8.1	148.0	506
7/5	C	52.5	16.2	21.5	27.0	1.58	0.88	10.2	4.1	27.8	948	2175	11136	14259	13	31	43.1	34.59	11	8.3	116.0	483
	III					3.05	2.32	19.0	1.0	57.8	1260	28700	1588	31548	76	85	61.7	31.34	20	8.3	241.0	667
	0.5			21.5		3.76	2.02	4.1	12.3	30.7	1422	5060	8280	14762	55	48	47.8	62.16	6	8.2	120.0	504
	3.5			21.2		1.48	1.45	11.1	15.1	28.8	1290	2915	9986	14191	23	40	44.5	32.53	5	8.3	120.0	509
	6.5			21.0		1.45	1.39	9.0	91.2	34.3	1462	5374	8383	15219	51	73	49.1	62.07	8	8.3	140.0	557
	9.5			19.5		3.26	2.42	5.4	9.2	35.0	1222	5774	9986	16982	89	105	50.9	33.30	16	8.3	143.0	561
7/10	C	52.3	10.5	20.0	26.5	3.04	1.08	18.5	7.5	28.6	860	3060	6238	10158	38	46	44.5	34.63	13	8.1	119.0	493
	III					4.76	3.29	24.8	10.3	56.4	1025	37250	1805	40080	73	85	49.7	31.41	50	8.1	235.0	685
	0.5			20.0		2.09	1.27	13.3	7.5	28.6	1160	3563	6000	10723	37	50	45.9	33.87	12	8.1	119.0	493
	3.5			19.8		2.31	1.49	13.3	7.4	29.3	1095	3060	6360	10515	36	46	45.0	33.96	11	8.1	122.0	476
	6.5			19.8		6.70	2.12	13.6	7.8	30.7	1000	3238	6252	10490	40	55	45.5	34.34	16	8.1	128.0	470
	9.5			19.2		8.90	2.62	12.2	8.7	27.8	1215	3613	6200	11028	45	59	44.0	33.07	12	8.2	116.0	500
7/17	C	51.8	14.7	22.0	26.0	1.00	0.66	13.1	6.7	26.9	980	3488	20304	24780	34	46	42.0	36.90	11	8.2	112.0	503
	III					3.46	2.39	18.4	0.5	57.4	928	30750	8200	39878	136	138	64.3	33.79	19	8.2	239.0	672
	0.5			22.0		1.45	1.35	16.0	6.7	27.1	1513	3512	16680	21705	34	44	42.7	34.71	28	8.2	113.0	527
	3.5			21.5		1.36	1.45	11.0	6.4	27.8	973	3812	16400	21185	30	40	42.7	34.62	15	8.2	116.0	503
	6.5			20.8		2.52	1.67	18.1	5.1	32.2	1163	5138	16960	23261	60	61	44.5	34.52	12	8.1	126.0	538
	9.5			20.2		2.58	1.63	9.9	4.1	38.5	1683	3738	16760	22181	64	77	44.8	34.07	14	8.1	127.0	585

APPENDIX 8. Continued

ANALYSES – INDIAN CREEK RESERVOIR

Date	Sample Type	Res. Depth	Secchi Disk	Temperature		Unfiltered Samples					0.45 µ Millipore Filtered Samples											
				Water	Air	Susp. Solids	Vol. Susp. Solids	COD	DO	Inorg. C	Nitrogen as N				Phosphorus as P		Ca	Cl⁻	Fe	pH	Alk. as CaCO$_3$	Cond. (10^{-6})
											Org.	NH$_3$	NO$_2$ + NO$_3$	Total	PO$_4$	Total						
		ft	ft	°C	°C	mg/l	mg/l	mg/l	mg/l	mg/l	µg/l	µg/l	µg/l	µg/l	µg/l	µg/l	mg/l	mg/l	µg/l		mg/l	mhos
7/23	C	51.0	10.2	20.0	24.0	2.42	1.08	13.9	7.6	29.8	1203	5990	8480	15673	43	64	42.6	37.62	<1	8.5	180.0	471
	III					4.23	2.98	19.1	0.8	65.1	818	34950	1510	37278	153	155	64.3	60.81	21	8.5	271.0	701
	0.5			20.0		2.52	2.21	14.6	7.6	30.0	1038	3438	8480	12956	48	61	42.7	39.86	9	8.4	125.0	488
	3.5			20.0		3.15	1.50	18.7	6.4	30.0	1088	3063	8840	12991	48	68	42.2	41.05	9	8.4	125.0	484
	6.5			20.0		3.31	1.50	14.2	7.9	28.8	1233	3188	8640	13061	53	77	42.2	41.21	9	8.4	120.0	488
7/31	C	50.5	10.7	21.0	24.0	1.41	0.99	12.5	9.1	28.6	693	2938	8640	12271	34	50	41.2	35.98	6	8.4	119.0	456
	III					7.06	5.08	19.8	0.8	65.3	713	35750	2640	39103	255	266	58.1	32.68	6	8.4	272.0	589
	0.5			21.0		2.13	1.67	15.8	9.1	28.8	908	3438	7760	12106	44	53	41.4	31.48	5	8.4	128.0	457
	3.5			21.0		1.93	1.61	16.2	11.3	28.8	918	3313	10480	14711	42	52	41.8	36.93	7	8.4	120.0	484
	6.5			20.2		2.64	1.53	14.2	7.7	29.3	1113	3688	10688	15489	55	71	42.1	36.21	2	8.3	122.0	456
8/8	C	48.5	14.0	21.2	22.0	1.63	0.69	12.5	9.0	28.8	883	3688	7088	11659	68	83	40.5	37.66	4	8.2	120.0	486
	III					1.46	1.26	14.5	1.5	62.6	728	35750	966	37444	242	242	51.2	33.70	<1	8.1	261.0	626
	0.5			21.2		1.79	1.27	14.2	9.0	29.5	1068	4438	6672	12176	59	156	42.1	34.43	11	8.2	123.0	481
	3.5			20.6		1.42	1.17	13.2	9.8	28.6	1268	4738	7660	13666	57	76	41.9	35.16	7	8.1	119.0	506
	6.5			20.6		1.60	1.39	12.2	10.6	28.6	1073	3788	7088	11949	51	331	41.0	36.07	5	8.2	119.0	494
8/14	C	47.2	11.2	19.2	17.0	3.09	1.09	10.2	8.3	28.5	1081	3338	1958	6377	49	60	40.5	35.61	12	8.4	116.0	504
	III					3.06	2.24	14.8	1.7	64.3	798	40750	200	41748	111	116	55.3	32.86	9	8.4	297.0	667
	0.5			19.2		2.48	1.52	13.8	8.3	30.0	1148	3688	1848	6684	60	76	40.2	36.07	10	8.2	120.0	531
	3.5			19.1		1.98	1.45	13.1	8.3	27.4	1138	3438	1984	6560	50	58	40.5	35.33	10	7.9	116.0	489
	6.5			19.0		2.95	1.98	12.8	10.2	29.5	1848	3663	2208	7719	55	68	40.2	35.70	6	8.2	118.0	535
8/21	C	46.0	15.5	18.2	19.5	2.18	0.87	11.6	8.8	28.6	872	2438	7920	11230	3	60	39.7	35.73	21	8.3	119.0	497
	III					5.12	3.99	18.7	0.9	55.0	663	7435	320	8418	3	68	52.6	33.55	15	8.3	229.0	586
	0.5			18.2		1.41	1.31	15.7	8.8	28.3	1143	3463	7640	12246	4	68	40.2	38.27	14	8.3	118.0	498
	3.5			18.0		1.91	1.57	14.3	9.8	28.6	1083	3488	8200	12771	5	61	40.7	35.82	19	8.3	119.0	496
	6.5			17.9		0.99	0.95	12.2	12.4	27.6	1473	2938	8080	12491	4	54	39.5	36.09	9	8.2	115.0	562
8/28	C	44.2	18.1	19.0	19.0	0.86	0.54	14.2	9.0	29.8	896	3938	1512	6346	44	66	41.0	39.37	13	8.3	126.0	497
	III					3.93	2.57	16.8	1.6	65.3	689		59		216	216	57.9	34.61	16	8.2	272.0	626
	0.5			19.0		1.00		13.9	9.0	30.2	1039	4988	1376	7601	42	68	41.4	35.54	37	8.4	126.0	481
	3.5			19.0		0.95		14.5	10.5	28.6	1183	3438	1660	6281	34	51	40.3	36.29	20	8.2	119.0	444
	6.5			19.0		0.77		16.8	11.0	27.6	1169	3438	1760	6367	32	50	40.5	37.22	33	8.2	115.0	488
9/5	C	42.3	21.5	18.0	19.5	0.49	0.45	10.6	7.9	28.8	673	3938	7360	11971	51	83	40.9	39.98	15	8.1	120.0	494
	III					3.81	2.61	14.7	1.5	97.8	588	27375	450	28413	142	164	68.6	35.50	10	8.1	241.0	621
	0.5			18.0		1.03	0.87	11.8	7.9	30.0	1068	4438	7640	13146	44	65	40.2	36.64	15	8.0	120.0	483
	3.5			17.9		0.85	0.98	12.1	8.2	28.1	833	3688	6760	11261	45	63	40.5	36.07	9	8.1	117.0	480
	6.5			17.9		0.97	1.04	11.4	9.9	28.1	923	2938	7504	11365	44	54	40.7	35.97	16	8.1	117.0	488
9/11	C	42.0	14.5	16.9	14.0	1.35	0.75	10.2	9.3	28.8	960	1038	5552	7550	40	52	41.8	35.91	13	8.2	120.0	495
	III					1.37	1.24	11.8	1.4	99.3	670	18650	370	19690	172	197	53.0	30.92	15	8.3	247.0	666
	0.5			16.9		1.60	1.25	10.5	9.3	29.0	1235	1138	5192	7565	38	57	42.4	33.98	12	8.2	121.0	505
	3.5			16.5		1.53	1.26	10.8	9.2	28.6	1040	1148	5780	7968	44	58	41.6	33.37	12	8.2	119.0	455
	5.5			16.5		4.35	1.77	14.1	9.6	28.6	1270	688	4732	6690	45	59	41.8	33.67	11	8.2	119.0	492
9/18	C	41.4	21.5	16.0	16.0	1.11	0.83	11.0	10.1	28.1	951	8750	9316	19017	22	38	41.9	36.84	6	8.2	117.0	439
	III					3.78	1.49	15.2	2.3	55.4	366	22650	184	23200	129	131	59.1	31.67	8	8.3	231.0	536
	0.5			16.0		1.53	1.98	14.0	10.1	29.3	1140	7650	7160	15950	40	59	40.5	35.53	13	8.2	122.0	491
	3.5			15.5		1.18	1.59	11.6	12.2	28.1	1226	7250	9320	17796	27	38	40.7	35.18	12	8.2	117.0	515
	6.5			15.0		2.66	2.66	13.1	11.9	28.6	1391	8750	7504	17645	21	31	40.0	36.40	9	8.1	119.0	497
9/25	C	41.9	22.2	14.0	10.0	1.32	0.68	13.4	8.4	28.1	1142	9550	7088	17780	36	43	40.2	33.76	23	8.2	117.0	483
	III					0.67	0.55	12.5	1.8	62.4	592	25875	657	27124	160	173	56.6	29.58	27	8.3	260.0	673
	0.5			14.0		1.60	1.27	13.1	8.4	30.3	937	10250	7784	18971	37	48	41.7	33.44	9	8.0	121.0	472
	3.5			13.7		1.27	1.28	14.9	11.7	27.4	1067	8750	8760	18577	29	39	41.0	34.65	23	8.1	114.0	472
	6.5			13.0		1.91	1.19	16.9	12.7	28.5	1192	8250	8452	17894	19	34	39.8	34.97	22	8.0	114.0	466
10/2	C	43.0	23.9	13.2	13.0	1.90	0.76	12.1	10.3	28.8	1448	5250	7924	14622	26	41	40.2	37.94	8	8.1	120.0	470
	III					4.29	3.47	10.3	1.8	56.9	594	29250	761	30605	209	209	59.3	30.83	16	8.1	237.0	582
	0.5			13.2		1.36	0.88	13.0	10.3	27.1	1594	6250	8064	15908	24	35	40.2	36.25	12	8.1	113.0	470
	3.5			13.2		1.26	1.02	13.9	11.6	26.6	1594	6250	8880	16724	22	32	40.0	36.73	16	8.0	111.0	459
	6.5			13.2		1.90	0.92	13.9	13.4	27.4	1624	7350	8320	17294	20	33	40.0	36.33	14	8.0	116.0	454
10/9	C	43.1	14.3	14.0	15.5	1.05	0.63	13.9	11.2	30.5	835	6250	7644	14729	27	38	40.2	42.69	34	8.0	122.0	500
	III					2.26	0.70	11.8	1.4	71.8	475	35550	134	36159	102	117	54.3	33.10	42	8.3	299.0	664
	0.5			14.0		1.36	1.04	13.3	11.2	30.2	1315	5550	7020	14085	27	38	40.5	38.74	22	8.2	126.0	508
	3.5			13.8		1.41	1.17	12.7	11.9	30.0	1035	5050	7644	13729	25	37	40.5	38.74	19	8.0	120.0	496
	6.5			13.8				13.0	14.5	31.2	1045	4687	7367	13099	24	49	40.5	38.93	35	8.0	125.0	521

APPENDIX 8. Continued

ANALYSES – INDIAN CREEK RESERVOIR

Date	Sample Type	Res. Depth	Secchi Disk	Temperature		Unfiltered Samples					.45 µ Millipore Filtered Samples											
											Nitrogen as N				Phosphorus as P		Ca	Cl^-	Fe	pH	Alk. as $CaCO_3$	Cond. (10^{-6})
		ft	ft	Water °C	Air °C	Susp. Solids mg/l	Vol. Susp. Solids mg/l	COD mg/l	DO mg/l	Inorg. C mg/l	Org. µg/l	NH_3 µg/l	$NO_2 + NO_3$ µg/l	Total µg/l	PO_4 µg/l	Total µg/l	mg/l	mg/l	µg/l		mg/l	mhos
10/16	C	43.2	18.0	12.0	8.0	1.53	0.73	14.3	10.6	29.0	1347	3762	7666	12753	32	48	42.9	36.87	11	8.0	121.0	686
	III					7.45	5.83	14.6	2.6	70.0	277	31750	276	32301	157	167	73.3	31.07	33	8.0	293.0	699
	0.5			12.0		4.59	1.78	14.6	10.6	29.3	1552	4375	9632	15359	31	43	50.0	35.27	26	8.0	122.0	477
	3.5			11.2		2.19	1.26	13.4	11.4	29.8	1437	4775	7992	14204	35	46	42.2	35.56	23	7.9	124.0	472
	6.5					1.72	1.09	13.1	13.4	28.6	1282	3297	7620	12199	38	42	42.6	36.16	22	7.9	119.0	466
10/20	C	43.7	19.7	10.8	7.0	1.76	1.10	13.8	10.5	26.9	881	3780	8204	12865	35	39	42.9	36.38	24	8.1	112.0	488
	III					3.57	2.81	11.8	2.3	71.5	371	27550	240	28161	334	382	43.6	28.94	31	8.0	286.0	693
	0.5			10.8				14.2	10.5	32.0	1061	5575	7640	14256	61	67	44.1	35.48	33	8.0	128.0	487
	3.5			10.8				13.8	10.6	30.8	981	4125	7360	12466	41	49	42.1	35.66	27	7.9	123.0	477
	6.5			10.5				14.5	11.4	31.0	1141	3125	8132	12398	43	49	41.7	35.75	24	7.8	124.0	475
10/30	C	44.1	17.7	8.7	4.0	0.79	0.49	14.3	11.8	28.6	1284	3848	2048	7180	37	51	43.8	36.21	12	8.3	119.0	501
	III					3.41	2.70	15.0	2.3	68.6	760	36340	360	37460	266	303	73.1	28.83	19	8.3	286.0	698
	0.5			8.7		1.32	1.20	16.6	11.8	31.2	1484	4205	1360	7049	49	62	43.8	34.52	11	8.3	130.0	523
	3.5			8.7		2.02	1.81	13.2	15.3	30.5	1075	3657	2208	6940	40	53	44.7	35.23	11	8.3	127.0	519
	6.5			8.5		5.27	2.01	13.6	[illegible]	36.3	1356	3372	2420	7148	40	52	45.3	35.14	10	8.2	126.0	514
16/6	C	44.5	12.0	7.9	7.1	1.14	0.73	14.6	9.4	29.5	1640	2787	9184	13611	42	62	45.0	34.00	15	8.3	123.0	480
	III					4.36	3.27	15.0	1.2	62.2	963	19152	399	20514	80	104	69.3	25.72	33	8.2	259.0	698
	0.5			7.9		1.66	1.35	15.0	9.4	29.3	1482	3620	8632	13334	38	63	45.9	34.16	4	8.3	122.0	485
	3.5			7.9		2.83	2.09	13.5	8.6	30.7	1573	3800	9152	14525	43	63	45.0	34.08	8	8.2	128.0	485
	6.5			7.9		3.90	1.61	13.9	8.9	30.9	1573	3895	8880	14248	47	65	45.2	34.08	4	8.2	129.0	485
11/13	C	44.8	11.4	5.9	7.0	1.38	0.65	17.8	10.4	28.1	1179	3395	8880	13454	51	66	45.7	37.41	18	8.2	117.0	510
	III					1.74	1.45	11.4	1.3	71.5	565	18248	360	19173	60	80	76.9	31.43	20	8.1	270.0	667
	0.5			5.9		2.25	1.51	13.2	10.4	31.6	1179	3157	8264	12600	50	66	45.9	34.65	16	8.2	132.0	508
	3.5			5.5		3.55	1.89	11.7	10.7	33.0	1603	3324	8920	13847	52	64	45.2	35.29	33	8.1	132.0	497
	6.5			5.5		2.35	1.35	13.9	10.6	32.8	1474	3110	8600	13184	48	64	45.7	35.20	16	8.1	131.0	508
11/20	C	45.2	20.0	4.5	3.0	0.83	0.65	15.1	9.8	31.9	1254	3810	8464	13528	60	73	47.9	35.21	14	8.1	133.0	525
	III					2.19	1.60	23.4	1.8	66.5	907	22960	225	24092	85	102	76.8	30.81	34	8.0	266.0	698
	0.5			4.5		1.87	1.18	12.6	9.8	32.4	1292	4095	7824	13211	62	75	56.2	37.24	23	8.1	135.0	536
	3.5			4.5		2.14	1.63	10.1	10.5	32.4	1135	3335	8296	12766	59	73	55.4	36.53	19	8.1	135.0	525
	6.5			4.5		2.21	1.49	8.3	13.0	32.2	1412	3286	8296	12994	59	75	55.2	38.12	18	8.1	134.0	515
11/27	C	45.7	23.9	3.9	4.5	0.87	0.55	13.7	10.1	31.9	1612	4786	8040	14438	61	74	47.4	40.23	23	8.0	133.0	566
	III					9.31	6.82	35.2	1.1	66.5	1321	24476	239	26036	26	40	73.3	29.79	30	7.9	266.0	700
	0.5			3.9		1.11	0.97	13.7	10.1	31.9	1297	4334	7424	13055	60	78	48.4	38.89	24	8.0	133.0	605
	3.5			3.9		1.42	1.10	13.0	10.6	32.4	1297	4048	8320	13665	58	80	48.3	38.79	26	8.1	135.0	566
	6.5			3.9		2.58	2.02	27.0	13.6	34.0	1283	4872	7232	13087	64	79	48.6	39.46	23	7.9	136.0	560
12/5	Grab C			2.5	3.0	2.23	1.12	11.3		31.4	1162	3881	6648	11691	66	60	46.8	35.16	20	8.0	131.0	488
	III					1.45	1.19	14.9		67.3	223	23334	152	23709	189	215	73.3	31.89	28	7.7	269.0	644

APPENDIX 8. Continued

ANALYSES – INDIAN CREEK RESERVOIR

Date	Sample Type	Res. Depth	Secchi Disk	Temperature		Unfiltered Samples					0.45 μ Millipore Filtered Samples											
				Water	Air	Susp. Solids	Vol. Susp. Solids	COD	DO	Inorg. C	Nitrogen as N				Phosphorus as P		Ca	Cl^-	Fe	pH	Alk. as $CaCO_3$	Cond. (10^{-6})
											Org.	NH_3	$NO_2 + NO_3$	Total	PO_4	Total						
		ft	ft	°C	°C	mg/ℓ	mg/ℓ	mg/ℓ	mg/ℓ	mg/ℓ	μg/ℓ	μg/ℓ	μg/ℓ	μg/ℓ	μg/ℓ	μg/ℓ	mg/ℓ	mg/ℓ	μg/ℓ		mg/ℓ	mhos
1972																						
12-11	Grab C			1.0	11.2	1.61	0.84	16.0		33.8	1377	5000	7016	13393	80	84	54.3	39.69	36	8.1	141	578
	III					2.94	0.78	13.4		65.3	353	22952	253	23558	366	371	69.1	27.46	27	7.8	261	664
12-26	Grab C III	47.3		2.0	5.5	1.18	0.72		10.5	32.9	1302	5167	7432	13901	74	82	48.1	36.38	34	8.1	137	550
1973																						
1-4	Grab C			2.0	5.6	1.54	0.80	16.7	8.9	33.8	1003	5476	6400	12879	101	143	51.2	37.68	15	8.1	141	521
	III					5.41	4.31	26.9	1.8	57.6	879	26570	218	27667	184	196	59.6	33.76	27	8.1	240	672
1-8	Grab C			2.0	2.0	0.71	0.51	12.5	12.5	34.6	1048	6120	5580	12748	93	105	51.9	34.90	23	7.9	144	566
	III					1.80	1.54	18.3	2.4	56.9	596	28100	183	28879	215	232	65.9	31.27	19	8.0	237	683
1-15	Grab C			2.5	8.0			24.1	10.6	31.9	1407	6000	5124	12531	97	114	51.7	34.32	27	8.0	133	537
	III					2.99	2.22	20.1	1.8	60.3	997	22952	200	24149	143	159	72.2	26.43	33	7.5	232	683
1-22	Grab C			2.5	0.0	3.32	1.01	14.8	13.8	36.5	1430	6215	4720	12356	97	110	49.3	33.72	29	8.2	182	527
	III					2.84	2.12	21.9	1.5	61.7	820	20856	169	21845	118	133	80.0	29.68	24	8.5	257	675
1-29	Grab C			3.0	1.0	3.25	1.49	13.3	13.2	36.0	1451	6950	5832	14233	108	126	51.4	31.51	21	8.3	150	522
	III					1.87	1.51	20.4	0.5	55.9	780	28000	211	28991	269	296	59.6	28.44	24	8.3	233	622
2-5	Grab C			3.2	2.8			14.3	12.9	35.5	933	7050	5486	13469	92	113	52.2	32.61	28	8.3	148	540
	III					2.44	1.47	17.1	2.6	57.4	704	23240	173	24117	101	114	69.8	39.67	22	8.3	239	680
2-13	Grab C			4.5	5.0	7.39	1.93	26.0	12.7	21.8	1069	2738	3210	7017	58	68	32.1	17.96	46	8.3	91	311
	III					1.23	1.13	20.0	2.0	61.2	773	23904	162	24839	398	417	71.2	36.60	26	8.3	255	676
2-20	Grab C			7.0	5.0	3.68	1.75	13.1	9.3	35.5	884	7024	4872	12780	108	120	52.6	32.86	22	8.4	148	549
	III					1.60	1.39	22.7	2.0	65.3	741	31619	117	32477	369	398	68.1	37.95	23	8.4	278	704
2-26	Grab C			7.1	10.0	25.33	4.93	17.0	11.0	36.5	1299	8760	5368	15407	93	107	54.5	36.45	24	8.3	152	528
	III					0.88	0.88	17.0	1.9	62.9	627	22840	197	23664	225	234	78.4	38.18	20	8.3	262	696
3-5	Grab C			4.1	6.0	5.89	4.46	17.3	14.0	35.8	1229	6770	6016	14015	38	65	52.1	34.32	23	8.1	149	554
	III					1.18	1.11	24.0	1.8	49.2	896	21500	270	22664	151	621	65.9	57.08	26	8.1	205	736
3-12	Grab C			6.5	6.8	8.69	4.84	15.5		34.1	1354	8405	4720	14479	51	64	50.9	35.26	22	8.1	142	541
	III					1.05	0.83	25.7		38.5	830	23846	410	25086	462	462	76.2	122.46	16	7.9	154	848
3-19	Grab C			7.2	9.1	13.77	4.54	[illegible]	[illegible]	33.8	1629	8126	9136	14891	65	79	51.0	35.37	8	8.3	141	545
	III					1.09	0.96	[illegible]	[illegible]	53.0	1348	27199	532	29079	419	430	70.2	56.61	45	8.2	221	698
3-26	Grab C	54.5	4.1	6.2	12.0	4.30	3.55	[illegible]	[illegible]	33.8	1053	10357	6600	18010	55	71	54.7	36.47	<1	8.1	141	528
	III					0.63	0.70	[illegible]	[illegible]	60.5	744	36190	728	37662	334	347	81.9	51.97	<1	8.3	252	693
	0.5			6.2		5.92	4.93	[illegible]	[illegible]	36.7	825	10357	6240	17422	51	68	55.2	33.74	22	8.3	153	506
	3.5			6.0		6.43	3.83	[illegible]	[illegible]	36.5	963	10000	6668	17631	52	70	55.9	33.55	16	8.3	152	517
	6.5			5.3		4.77	3.30	[illegible]	[illegible]	39.6	1139	9762	6780	17681	65	81	55.7	33.36	23	8.3	165	506
	9.5			5.0		6.65	3.36	[illegible]		42.7	839	10310	6112	17261	69	86	55.7	33.83	5	8.3	178	512
4-3	Grab C			8.0	11.0	6.34	5.49	17.1	9.1	36.5	1063	7665	4232	12960	9	34	54.7	35.56	24	8.3	152	523
	III					0.65	0.74	16.8	3.0	50.6	681	28572	134	29387	497	540	61.4	44.63	38	8.2	211	632
4-9	Grab C	55.0	5.3	9.5	13.9	4.17	3.24	15.7	15.0	35.5	1358	5714	4316	11388	9	23	53.8	35.31	21	8.3	148	549
	III					0.75	0.67	18.7	3.0	49.7	891	16476	183	17550	430	462	58.3	35.89	33	8.2	207	583
	0.5			9.5		4.64	3.66	17.5	15.0	36.0	1272	5500	4092	10864	12	26	56.0	34.53	8	8.4	150	523
	3.5			9.0				16.3	17.0	36.7	1263	5810	4512	11585	20	37	55.2	33.85	31	8.4	153	523
	6.5			9.0		6.22	5.17	15.1	15.0	36.5	1598	5333	3952	10883	12	27	55.2	33.07	22	8.4	152	526
	8.5			8.7		46.80	14.61	23.2	14.3	35.3	1768	5238	4428	11434	15	32	54.1	36.05	16	8.3	147	616
4-16	Grab C	55.4		10.2	9.0	16.41	3.79	17.5	11.7	32.6	1023	7380	3212	11615	36	46	53.6	32.97	19	8.3	136	522
	III					1.20	0.94	22.9	1.8	48.5	695	17142	37	17874	318	322	69.0	48.82	26	8.2	202	576
4-23	Grab C	55.7	28.5	10.8	14.8	1.38	0.71	12.8	9.4	35.8	1102	7261	4066	12427	46	68	55.0	34.20	18	8.3	149	528
	III					0.80	0.64	10.2	1.9	54.2	978	20572	120	21270	185	199	69.3	37.14	30	8.3	226	660
	0.5			10.8		1.68	0.98	12.5	9.4	36.7	1365	6167	3576	11088	55	75	56.0	34.29	28	8.4	153	558
	3.5			10.5		3.58	2.12	12.8	9.4	36.7	1578	7048	4024	12650	55	77	55.3	34.46	21	8.4	153	529
	6.5			10.0		1.69	1.22	14.0	10.2	35.8	1707	6834	3452	11993	60	80	54.8	34.64	21	8.4	168	518
	8.5			10.0		5.22	3.07	16.4	9.5	35.3	1111	7024	4160	12295	59	80	54.0	33.39	24	8.3	167	518

APPENDIX 8. Continued

ANALYSES – INDIAN CREEK RESERVOIR

Date	Sample Type	Res. Depth	Secchi Disk	Temperature		Unfiltered Samples					0.45 μ Millipore Filtered Samples											
				Water	Air	Susp. Solids	Vol. Susp. Solids	COD	DO	Inorg. C	Nitrogen as N				Phosphorus as P		Ca	Cl⁻	Fe	pH	Alk. as $CaCO_3$	Cond. (10^{-6})
											Org.	NH_3	$NO_2 + NO_3$	Total	PO_4	Total						
		ft	ft	°C	°C	mg/l	mg/l	mg/l	mg/l	mg/l	μg/l	μg/l	μg/l	μg/l	μg/l	μg/l	mg/l	mg/l	μg/l		mg/l	mhos
4-30	Grab C	55.9	24.8	12.1	13.0	2.08	1.04	17.3	7.8	28.8	1592	7154	4228	12974	52	73	58.6	35.20	18	8.2	120	514
	III					0.59	0.54	13.1	2.1	60.9	706	21618	298	22622	287	304	89.7	30.61	34	8.3	252	694
	0.5			12.1		2.19	1.59	18.5	7.8	17.3	1225	7630	4412	13267	64	82	55.3	33.61	20	8.3	72	526
	3.5			12.0		2.50	1.74	17.0	8.2	35.8	1735	8024	4160	13919	66	85	55.2	32.49	19	8.3	149	526
	6.5			12.0		1.80	1.39	16.4	9.3	36.5	1573	6595	4300	12468	76	90	56.7	33.42	12	8.3	152	526
	9.5			12.0		30.12	8.60	36.7	10.3	35.5	1525	6310	4272	12107	68	84	57.4	32.67	22	8.3	148	526
5-7	Grab C	56.0	25.0	14.0	16.0	6.27	1.15	15.1		39.4	1562	7143	4580	13285	52	74	57.1	40.96	20	8.2	164	554
	III																					
	0.5			14.0		2.08	1.25	14.3		41.5	1614	7500	4036	13150	39	70	57.1	39.33	30	8.3	173	566
	3.5			12.9		1.84	1.33	16.3		39.1	1362	7929	3604	12895	52	71	57.8	39.84	21	8.3	163	571
	6.5			12.0		1.88	1.62	16.3		40.8	1552	7143	4692	13387	51	68	57.2	36.48	14	8.3	170	582
	9.5			11.8		2.02	1.69	15.7		40.1	1595	7070	4580	13249	51	68	58.3	36.28	9	8.3	167	591
5-14	Grab C	56.3	19.6	15.0	17.3	1.39	0.85	14.9	11.0	37.0	1472	5739	4160	11371	51	68	58.1	49.90	15	8.3	154	513
	III					1.31	1.13	13.7	1.9	65.3	735	20998	253	21986	126	148	85.9	32.39	8	8.3	272	672
	0.5			15.0		1.42	1.39	15.4	11.0	37.4	1669	8214	3604	13487	52	63	60.0	46.21	11	8.3	156	538
	3.5			14.9		1.97	1.60	15.4	12.9	37.0	1258	7334	4452	13044	55	70	59.0	45.64	8	8.2	154	515
	6.5			14.9		1.55	1.32	14.0	15.9	36.2	1857	7262	4440	13559	57	71	57.9	43.56	3	8.2	151	513
	9.5			14.4		2.29	1.91	16.3	10.9	35.8	1777	7025	3924	12726	57	70	57.6	39.96	15	8.2	149	504
5-21	Grab C	56.4	14.7	16.5	16.2	1.49	1.09	11.8	8.2	37.4	1217	7619	6000	14836	58	83	57.9	36.90	10	8.2	156	504
	III					1.31	0.91	9.1	0.7	64.8	803	23524	995	25322	83	97	89.5	33.23	<1	8.3	270	715
	0.5			16.5		2.51	1.54	12.1	8.2	34.7	1327	7262	5416	14005	56	74	54.8	35.63	<1	8.2	156	556
	3.5			16.2		2.40	1.96	12.9	7.1	37.7	1712	7381	6196	15289	49	71	60.0	38.77	<1	8.2	157	561
	6.5			16.5		1.91	1.41	14.3	8.0	36.5	1298	7381	6416	15095	59	73	59.1	38.70	<1	8.2	152	550
	9.5			16.5		1.63	1.37	10.7	8.6	36.7	993	7429	5692	14114	53	73	58.8	39.00	21	8.2	153	578
5-28	Grab C	46.3	14.6	17.2	18.8	1.70	1.11	14.5	8.0	35.0	1536	8214	3952	13702	43	64	57.8	39.33	6	8.2	146	512
	III					1.34	0.84	14.5	1.3	53.8	700	24286	162	25148	138	142	62.1	33.28	16	8.2	224	596
	0.5			17.2		3.06	1.92	17.2	8.0	37.2	1296	7262	3600	12158	55	71	56.6	31.93	8	8.2	155	528
	3.5			16.9		3.11	2.12	15.0	8.6	37.9	1438	7500	4000	12938	54	65	57.2	32.80	7	8.2	158	512
	6.5			16.0		2.76	2.03	15.0	11.0	37.2	1583	7740	3880	13203	57	68	56.0	32.56	2	8.2	155	512
	9.5			16.0		2.69	1.76	15.6	11.4	36.7	1517	6548	3672	11737	61	73	57.6	31.53	11	8.2	153	528
6-4	Grab C	56.3	9.1	17.8	13.2	2.81	2.81	21.2	11.0	37.7	1225	9167	3772	14164	24	51	57.1	40.47	21	8.4	157	506
	III					0.51	0.50	18.0	3.1	54.5	839	31048	100	31987	34	64	70.2	30.74	12	8.3	227	600
	0.5			17.8		5.48	4.56	23.2	11.0	37.9	1453	8929	2700	13082	22	43	59.5	37.16	9	8.4	158	517
	3.5			17.5		5.08	4.61	18.8	11.2	37.7	1829	9429	3688	14946	24	51	58.8	36.67	28	8.4	157	528
	6.5			17.0		2.72	2.40	18.4	10.6	37.4	1648	9714	3672	18034	51	80	57.8	36.87	9	8.4	156	523
	9.5			16.5		17.52	7.76	32.0	8.2	38.4	1610	9405	4860	15875	84	109	57.1	36.87	21	8.4	160	523
6-11	Grab C	56.4	16.0	19.5	19.0	1.[illegible]4	1.49	15.5	10.2	34.6	1480	6357	3436	11273	23	40	57.4	37.65	7	8.4	144	538
	III					1.16	1.05	11.0	1.8	56.4	613	23810	150	24573	74	86	67.1	32.94	<1	8.2	235	627
	0.5			19.5		1.96	1.96	17.1	10.2	37.7	1623	6572	2308	11103	18	36	57.9	37.65	1	8.4	157	526
	3.5			19.0		2.12	2.09	16.7	11.0	37.7	1766	6619	3436	11821	24	40	57.2	38.24	4	8.4	157	515
	6.5			18.6		2.34	2.08	16.7	11.8	37.2	1956	6548	3336	11860	30	44	56.9	37.75	21	8.4	155	515
	9.5			18.0		2.26	2.11	17.5	7.9	37.9	1089	6400	3072	10661	52	68	57.2	37.75	<1	8.3	158	515
6-18	Grab C	56.4	17.8	17.2	14.5	0.97	0.73	13.4	8.5	40.0	1239	6786	3160	11185	45	64	56.2	33.48	<1	8.2	154	533
	III					4.03	3.15	10.6	1.9	56.2	648	23904	169	24721	95	101	67.2	33.56	7	8.2	234	644
	0.5			17.2		1.72	1.72	13.8	8.5	39.4	1514	7405	2476	11395	54	70	57.9	33.74	<1	8.2	164	533
	3.5			17.0		1.57	1.57	12.6	9.2	38.6	1610	7476	3256	12342	45	63	57.1	34.52	2	8.2	161	533
	6.5			16.5		1.64	1.52	12.2	10.8	38.2	1610	6667	3188	11465	47	64	56.9	34.43	<1	8.2	159	533
	9.5			16.5		3.32	1.73	13.4	12.1	37.9	1514	6738	2516	10768	47	65	56.7	33.48	9	8.2	158	544
6-25	Grab C	56.3	16.0	18.5	19.6	1.23	0.84	15.7	9.0	37.0	1639	6714	3590	11943	24	71	57.4	37.81	1	8.4	154	523
	III					0.98	0.74	13.3	2.7	57.8	748	23524	208	24480	95	108	63.1	36.92	7	8.1	241	616
	0.5			18.5		2.35	2.14	18.9	9.0	38.4	1672	7929	3311	12912	45	71	58.3	36.57	<1	8.3	160	528
	3.5			18.0		2.21	2.17	19.7	8.6	38.2	1782	7000	3423	12205	49	74	58.1	37.72	<1	8.3	159	527
	6.5			17.6		1.72	1.70	15.3	9.1	37.7	1596	7262	3423	12281	42	80	57.2	37.72	<1	8.3	157	527
	9.5			17.2		1.29	1.28	14.9	10.4	37.9	1391	7524	2907	11822	51	93	57.8	37.28	7	8.3	158	527
7-2	Grab C	56.4	17.5	19.0	23.0	1.23	0.76	15.3	9.4	36.2	1336	6762	3312	11410	62	93	57.2	38.59	<1	8.2	151	468
	III					3.40	2.03	11.3	2.4	62.9	646	27809	159	28614	111	166	65.0	31.74	1	7.9	262	651
	0.5			19.0		2.24	1.72	12.9	9.4	37.4	1298	7738	2808	11844	51	86	58.3	39.03	<1	8.2	156	521
	3.5			19.0		1.82	1.75	13.3	8.1	39.4	1426	7929	3464	12819	51	90	58.1	37.68	3	8.0	164	504
	6.5			19.0		1.50	1.39	14.1	10.2	38.4	1288	7452	3436	12176	62	88	57.1	37.23	<1	8.1	160	491
	9.5			18.8		1.52	1.20	13.7	9.8	38.4	1246	6810	2780	10836	56	86	57.8	42.36	<1	8.2	160	491

APPENDIX 8. Continued

ANALYSES – INDIAN CREEK RESERVOIR

				Temperature		Unfiltered Samples					0.45 μ Millipore Filtered Samples											
Date	Sample Type	Res. Depth	Secchi Disk	Water	Air	Susp. Solids	Vol. Susp. Solids	COD	DO	Inorg. C	Nitrogen as N				Phosphorus as P		Ca	Cl⁻	Fe	pH	Alk. as $CaCO_3$	Cond. (10^{-6})
											Org.	NH_3	$NO_2 + NO_3$	Total	PO_4	Total						
		ft	ft	°C	°C	mg/l	mg/l	mg/l	mg/l	mg/l	μg/l	μg/l	μg/l	μg/l	μg/l	μg/l	mg/l	mg/l	μg/l		mg/l	mhos
7-9	Grab C	55.9	14.0	21.0	22.0	1.15	0.86	16.4	8.3	37.4	1722	6070	3452	11244	71	73	57.4	39.20	<1	8.4	156	593
	III					1.68	1.68	18.4	0.4	57.0	575	24760	121	25456	160	175	62.6	35.13	<1	8.4	241	627
	0.5			21.0		2.02	1.69	19.2	8.3	38.4	1632	6786	2692	11110	52	71	58.1	38.54	<1	8.3	160	593
	3.5			20.5		2.00	2.00	16.8	9.3	38.9	1803	7024	2768	11595	46	76	58.3	39.70	<1	8.4	162	593
	6.5			20.0		1.03	1.11	14.0	8.6	37.9	1622	6524	3576	11722	65	83	58.8	38.37	<1	8.3	198	588
	9.5			20.0		0.85	0.85	14.4	9.0	38.6	1670	6357	2976	11003	64	86	57.9	38.12	3	8.3	161	605
7-17	Grab C	54.0	14.6	21.0	20.5	1.15	0.87	17.8	7.2	38.4	1636	6166	3868	11670	71	76	57.6	34.30	<1	8.3	160	535
	III					0.91	0.79	15.0	1.3	62.9	922	24476	117	25515	143	159	63.4	29.44	<1	8.2	262	633
	0.5			21.0		1.49	1.31	13.4	7.2	37.9	1579	5857	2921	10357	57	73	58.3	31.31	<1	8.4	158	536
	3.5			20.5		1.49	1.49	14.2	6.8	37.4	1636	5643	3883	11162	52	71	57.9	32.60	<1	8.4	156	536
	6.5			20.0		1.43	1.27	15.0	6.7	37.4	1708	5143	3868	10719	55	71	57.2	30.97	<1	8.3	156	536
7-23	Grab C	52.8	15.5	20.2	24.6	1.21	0.85	10.6	8.0	33.6	1280	4550	5416	11246		72	72.6	34.34	<1	8.2	140	515
	III					3.18	2.74	16.7	1.8		290	16800	553	17643		178	73.4	30.27	1			571
	0.5			20.2		1.17	1.17	10.6	8.0	38.4	1090	4600	3536	9226		71	73.8	35.47	<1	8.4	160	514
	3.5			20.0		1.24	1.28	8.5	8.9	37.7	1435	3600	4816	9851		76	74.5	36.37	<1	8.4	157	514
	6.5			20.0		1.25	1.25	8.1	9.1	37.4	1430	4150	3296	8876		79	74.0	35.62	<1	8.4	156	514
	9.5			20.0		1.59	1.35	13.8	8.7	38.2	1320	4800	3144	9264		73	74.3	35.62	<1	8.4	159	514
8-6	Grab C	50.1	18.8	19.7	28.0	2.43	1.83	14.9	7.3	35.0	810	3375	4648	8833	44	44	69.6	36.64	<1	8.3	146	513
	III					4.10	2.60	22.4	0.9	53.5	615	20700	100	21415	107	131	76.8	39.19	3	8.2	223	653
	0.5			19.7		1.43	1.03	15.7	7.3	34.6	810	3075	5864	9749	46	74	70.9	35.89	<1	8.3	144	489
	3.5			19.2		1.66	1.47	14.5	7.5	36.0	870	3575	4512	8957	44	68	70.9	35.36	<1	8.4	150	489
	6.5			19.2		1.25	1.21	14.9	7.5	35.3	945	3075	6000	10020	42	59	68.3	36.26	<1	8.3	147	489
	8.5			19.2		0.79	0.79	16.1	7.6	35.5	720	3575	4776	9071	42	62	72.2	36.71	<1	8.3	148	489
8-13	Grab C	49.3	20.0	20.2	22.5	1.48	0.89	16.5	7.2	32.2	770	3000	4188	7958	32	44	63.3	38.21	<1	8.2	134	518
	III					1.06	0.96	20.1	1.4	60.0	370	21810	277	22457	58	126	80.7	39.04	<1	8.3	250	702
	0.5			20.1		1.93	0.77	19.3	7.2	33.1	1770	2905	4996	9671	29	40	64.8	36.86	<1	8.3	138	529
	3.5			20.1		1.06	0.45	19.3	7.8	33.1	1245	2905	6184	10334	29	40	63.1	37.16	3	8.3	138	529
	6.5			20.1		0.82	0.36	17.7	7.6	32.4	1320	2600	6184	10104	30	44	63.1	35.06	<1	8.3	135	524
	8.5			20.0		0.81	0.31	15.0	8.0	33.1	1460	2600	4996	9056	32	45	63.1	30.71	<1	8.3	138	518
8-20	Grab C	48.0	18.1	19.5	19.8	0.87	0.64	13.3	6.8	30.5	625	2050	7152	9827	28	32	59.8	38.51	<1	8.2	127	503
	III					1.74	1.05	17.7	1.9	50.4	290	20400	661	21351	160	160	64.7	39.96	1	8.3	210	638
	0.5			19.5		1.03	0.97	14.5	6.8	31.0	625	2220	5952	8797	22	30	53.6	32.60	<1	8.2	129	519
	3.5			19.5		1.60	1.44	14.5	6.8	31.0	670	1740	7232	9642	20	30	52.9	36.57	<1	8.3	129	512
	6.5			19.0		1.21	1.10	12.6	6.6	30.7	860	820	7736	9416	18	24	52.8	39.27	<1	8.2	128	487
	8.5			19.0		1.06	1.06	14.9	6.2	30.0	180	1450	6368	7998	20	24	53.4	35.52	<1	8.2	125	491
8-27	Grab C	45.8	23.9	17.0	18.9	0.76	0.50	15.7	6.3	28.1	615	2625	8880	12120	31	43	51.4	37.30	<1	8.4	117	504
	III					2.79	2.30	23.7	2.1	48.5	535	22400	758	23693	291	298	57.9	40.27	<1	8.3	202	606
	0.5			17.0		1.14	1.02	13.3	6.3	29.5	870	1450	7512	9832	24	33	52.1	35.69	<1	8.3	123	482
	3.5			16.9		1.07	1.08	13.7	6.6	29.5	1020	790	8192	9922	22	30	51.9	36.90	<1	8.4	123	482
	6.5			16.2		1.38	0.95	13.3	7.5	29.3	975	1750	8104	10829	15	35	50.3	35.48	<1	8.4	122	482
9-4	Grab C	44.6	20.5	17.0	19.2	1.00	0.73	13.7	10.5	27.1	925	1350	6504	8779	19	44	49.4	39.22	<1	8.3	113	506
	III					1.55	1.23	28.9	1.1	54.5	765	18260	134	19159	80	151	62.4	46.75	<1	8.3	227	660
	0.5			17.0		1.01	0.95	11.7	10.5	29.0	810	840	6316	7966	13	42	50.3	39.40	<1	8.2	121	512
	3.5			16.7		1.11	1.11	12.9	11.0	28.6	715	700	6372	7787	12	39	48.8	41.64	<1	8.3	119	509
	6.5			16.5		1.97	1.11	12.9	10.2	28.6	925	660	5834	7419	10	36	48.4	41.54	<1	8.2	119	516

APPENDIX 8. Continued

ANALYSES – INDIAN CREEK RESERVOIR

Date	Sample Type	Res. Depth	Secchi Disk	Temperature		Unfiltered Samples						0.45 μ Millipore Filtered Samples											
				Water	Air	Susp. Solids	Vol. Susp. Solids	COD	DO	Inorg. C	Total Phos. as P	Nitrogen as N				Phosphorus as P		Ca	Cl⁻	Fe	pH	Alk. as $CaCO_3$	Cond. (10^{-6})
												Org.	NH_3	$NO_2 + NO_3$	Total	PO_4	Total						
		ft	ft	°C	°C	mg/l	mg/l	mg/l	mg/l	mg/l	μg/l	μg/l	μg/l	μg/l	μg/l	μg/l	μg/l	mg/l	mg/l	μg/l		mg/l	mhos
9-10	Grab C	42.4	17.0	17.0	11.8	0.75	0.59	12.5	12.2	27.4	16	475	1475	7224	9174	6	12	47.2	42.33	<1	8.2	116	520
	III					0.83	0.69	18.1	1.8	53.3	37	565	19400	228	20193	21	25	57.6	39.64	<1	8.2	222	640
	0.5			17.0		1.28	1.02		12.2	28.1	17	690	1290	6224	8124	3	13	47.9	38.35	<1	8.1	117	523
	3.5			16.6		1.16	1.15	16.9	12.9	28.3	15	775	725	7048	8548	3	10	46.0	40.34	<1	8.2	118	506
	6.5			16.4		38.31	7.13	15.7	13.4	27.1	17	845	600	6140	7605	3	15	45.9	49.00	<1	8.1	113	509
9-17	Grab C	40.9	18.6	17.2	19.5	0.96	0.56	15.7	10.2	31.0	26	675	2400	6084	9159	4	14	47.4	40.18	7	8.2	120	517
	III					9.21	5.12	29.8	1.3	60.7	123	415	20300	155	20870	22	93	72.4	32.00	16	8.3	253	671
	0.5			17.2		0.89	0.69	14.1	10.2	28.8	24	1270	2200	5024	8494	5	14	47.4	38.64	<1	8.1	120	506
	3.5			16.9		1.17	0.92	14.9	10.5	29.5	40	1070	2300	6252	9622	3	12	46.5	38.36	<1	8.1	123	506
	5.5			16.6		1.48	0.89	12.5	13.1	28.1	15	990	1590	6184	8724	4	12	48.6	40.00	<1	8.1	117	508
9-24	Grab C	41.3		15.3	12.7	7.10	1.76	16.0	9.4	28.6	18	310	975	6392	7677	4	12	43.8	39.63	<1	8.1	119	487
	III					1.12	0.76	21.7	0.7	61.2	38	335	18700	75	19110	14	24	76.0	42.87	5	7.7	295	693
10-1	Grab C	41.9	22.0	14.0	18.4	1.03	0.51	21.5	10.7	28.3	10	610	1500	5834	7944	3	10	44.0	44.93	12	8.2	118	552
	III					0.83	0.63	17.5	1.2	61.0		345	19100	64	19509			67.4	39.90	1	8.2	284	575
	0.5			14.0		1.36	0.91	14.6	10.7	27.8		980	975	4552	6507	1	8	44.0	41.35	<1	8.2	116	505
	3.5			14.0		1.31	1.06	15.0	9.7	25.2		725	1150	6043	7918	2	8	43.8	41.98	<1	8.2	105	505
	5.5			14.0		4.73	1.78	15.5	9.5	28.1		895	1475	4594	6964	1	8	43.3	41.15	<1	8.1	117	505
10-8	Grab C	42.0	19.6	11.2	8.9	1.61	0.84	16.7	7.8	30.0	4	270	2100	5292	7662	3	4	44.7	41.87	7	8.3	126	510
	III					0.92	0.70	20.7	1.2	60.7	11	145	23400	210	23755	5	8	76.0	39.10	24	8.3	253	683
	0.5			11.2		1.29	0.89	15.5	7.8	27.8	4	1045	2025	4176	7246	1	1	45.5	39.27	14	8.2	116	495
	3.5			11.2		1.17	0.81	16.7	7.5	25.0	5	995	2075	5832	8902	1	3	44.8	41.61	9	8.2	106	504
	6.5			11.2		2.42	0.85	15.5	7.1		4	1215	850	5804	7869	1	3	44.1	41.52	7			504
10-15	Grab C	42.6	21.6	16.8	18.5	0.83	0.51	14.4	8.1		5	230	1350	6043	7623	2	3	45.9	43.98	22			504
	III					1.07	0.87	14.8	2.3		13	110	10700	120	10930	8	9	63.8	39.35	25			650
	0.5			16.8		0.94	0.91	14.8	8.1		5	970	1325	4468	6763	1	5	45.0	43.80	14			515
	3.5			16.2		0.97	0.88	14.4	9.4		5	1180	875	4748	6803	1	5	45.9	43.80	15			549
	6.5			16.0		1.96	1.01	15.2	8.2		5	1200	925	4788	6913	1	5	45.2	42.87	16			515
10-22	Grab C	43.0		12.2	14.1	10.34	3.00	16.8	8.5		24	1154	950	8881	10985	1	12	47.1	41.93	23			519
	III					0.95	0.47	11.6	0.6		23	20	13200	52	13272	9	20	64.5	35.13	27			683
10-29	Grab C	43.4	15.3	10.0	8.5	1.04	0.67	15.0	7.7	32.2	5	760	2798	5416	8974	1	3	47.8	40.98	11	8.2	136	540
	III					0.28	0.28	12.6	0.9	67.0	33	188	30238	111	30537	28	33	65.5	34.76	14	8.1	279	705
	0.5			10.0		1.11	0.94	14.6	7.7	32.0	8	607	3298	4064	7969	1	5	47.6	42.47	12	8.3	134	566
	3.5			9.5		2.60	2.35	18.6	8.2	31.2	4	960	2465	5848	9253	<1	4	47.1	40.90	12	8.3	130	559
	6.5			9.1		2.27	1.31	16.6	8.6	30.2	3	802	2250	4832	7884	<1	3	47.2	38.27	6	8.3	176	549
11-6	Grab C	43.9	12.0	6.4	13.9	2.20	0.91	15.8	8.3	31.9	6	845	2798	6876	10519	1	6	47.4	45.07	25	8.2	133	547
	III					0.37	0.37	9.3	1.1	69.1	34	60	25380	124	25564	34	34	76.1	33.25	19	8.2	288	706
	0.5			6.4		2.99	1.33	15.4	8.3	32.4	6	1283	3321	4580	9184	2	6	48.1	45.32	12	8.1	135	536
	3.5			6.2		3.57	2.03	14.6	7.9	31.7	6	1298	2679	6360	10337	2	5	47.1	40.82	12	8.1	132	538
	6.5			6.2		2.79	1.41	14.6	8.0	31.2	6	1317	2440	6252	10009	3	3	47.6	39.37	9	8.1	130	538
11-13	Grab C	44.5		7.5	6.4	13.20	3.51	13.1		27.8	12	1012	1607	6316	8935	4	10	49.1	41.29	27	8.4	116	571
	III							11.5	1.1	49.7	41	136	16048	302	16486	32	37	54.7	23.96	22	8.3	207	600
11-19	Grab C	45.1	17.0	4.2	4.0	1.51	0.88	14.6	8.8	26.4	6	660	2155	6531	9346	2	6	50.1	47.82	15	8.2	118	566
	III					0.61	0.94	20.6	1.0	58.6	26	140	27000	116	27256	21	25	65.7	34.92	19	8.2	244	681
	0.5			4.2		2.76	1.23	17.8	8.8	31.4	8	526	2702	5695	8923	2	6	52.6	41.03	2	8.2	131	552
	3.5			4.0		2.93	1.61	16.6	8.3	31.7	5		2441	5972		2	5	50.1	40.77	12	8.1	132	555
	6.5			4.0		3.53	1.64	17.4	8.2	31.7	6	917	2580	4580	8057	2	5	51.4	40.64	9	8.1	132	535

APPENDIX 8. Continued

ANALYSES – INDIAN CREEK RESERVOIR

Date	Sample Type	Res. Depth	Secchi Disk	Temperature		Unfiltered Samples						0.45 µ Millipore Filtered Samples											
				Water	Air	Susp. Solids	Vol. Susp. Solids	COD	DO	Inorg. C	Total Phos. as P	Nitrogen as N				Phosphorus as P		Ca	Cl⁻	Fe	pH	Alk. as $CaCO_3$	Cond. (10^{-6})
												Org.	NH_3	$NO_2 + NO_3$	Total	PO_4	Total						
		ft	ft	°C	°C	mg/l	mg/l	mg/l	mg/l	mg/l	µg/l	µg/l	µg/l	µg/l	µg/l	µg/l	µg/l	mg/l	mg/l	µg/l		mg/l	mhos
11-26	Grab C III			5.8	3.1	2.87 0.64	0.85 0.61	9.5 14.6	9.2 0.6	26.9 61.9	16 131	817 464	2274 29380	6392 113	9483 29957	9 126	12 127	51.4 61.2	40.86 29.45	16 8	8.3 8.3	112 258	540 645
12-4	Grab C III				2.0	0.81	0.47	9.5		30.7	19	707	2917	5876	9500	15	16	51.7	39.90	9	8.2	128	538
12-10	Grab C III			7.1	11.1	0.79 0.44	0.43 0.44	13.2 17.6	12.2 1.6	31.7 61.0	21 48	940 502	2060 15000	6128 107	9128 15609	17 39	18 39	52.1 73.3	41.70 35.47	9 23	8.2 8.2	132 254	526 648
12-17	Grab C III			4.0	8.4	1.07 0.54		9.5 14.2	11.1 1.4	31.2 61.2	21 43	864 407	2607 26904	6000 169	9471 27480	16 39	19 40	54.7 67.9	36.43 31.33	17 19	8.2 8.2	130 255	543 667
12-26	Grab C III			4.0	11.0	21.96 2.21	3.56 1.50	11.3 13.8	10.9 1.9	31.0 63.1	19 41	898 436	2893 27380	6544 211	10335 28027	17 38	18 38	52.4 71.0	35.43 32.67	13 17	8.2 8.2	129 263	536 661
1974																							
1-14	Grab C III					7.23 3.99	1.60 2.76	18.0 24.2	9.0 0.4	35.8 58.8	46 50	960 498	5415 23476	5420 96	11795 24070	26 29	43 47	54.3 73.8	36.56 40.31	17 40	8.3 8.3	149 245	551 691
1-21	Grab C III			6.0	-1.5	1.16 1.18	0.47 0.96	12.3 13.5	9.6 1.0	34.8 61.0	26 33	831 169	5179 21570	5290 67	11300 21806	18 20	18 21	51.7 80.5	55.00 35.26	28 16	8.3 8.3	145 254	528 655
1-28	Grab C III			6.5	9.1	4.09 1.35	0.97 1.01	14.9 17.2	10.9 0.7	32.2 62.2	35 101	1045 474	5618 16142	5264 78	11927 16694	32 77	32 79	53.6 77.9	40.05 55.89	7 41	8.3 8.3	134 259	528 693
2-4	Grab C III			5.9	7.2	6.48 1.48	1.69 1.06	14.3 13.5	12.2 1.2	32.6 62.9	35 106	1279 431	5179 22714	5540 97	11998 23242	28 62	32 64	54.1 68.3	40.20 42.36	10 22	8.3 8.3	136 262	550 689
2-11	Grab C III			5.5	12.0	24.14 0.99	3.54 0.70	18.9 16.5	 0.9	35.5 64.6	50 38	912 407	6179 24524	5555 83	12646 25014	30 32	30 37	55.3 78.6	39.36 40.16	12 17	8.3 8.3	140 269	539 704
2-20	Grab C III			5.3	1.5	1.63 0.79	0.57 0.51	11.3 12.9	11.9 2.2	35.5 60.5	35 40	1026 192	5655 17667	5108 90	11789 17949	27 25	32 34	53.1 71.4	39.23 38.08	17 7	8.2 8.2	148 252	539 688
2-25	Grab C III			9.0	13.5	8.27 1.19	1.74 0.85	12.6 18.3	12.1 1.0	35.8 63.6	31 57	964 307	6131 26618	4968 90	12063 27015	20 44	29 49	54.1 67.2	38.55 33.21	19 17	8.2 8.2	149 265	533 682
3-4	Grab C III					3.57 1.18	1.22 0.94	11.3 12.9	9.3 1.9	33.4 60.7	76 95	1088 283	5679 21666	4692 55	11459 22004	30 54	57 92	53.6 69.5	37.00 28.97	10 2	8.2 8.2	139 253	528 680
3-12	Grab C III			8.2	7.1	121.20 0.98	12.72 0.68	15.9 26.1	 1.2	37.0 61.7	34 77	907 260	5684 19286	4858 78	11449 19624	24 65	31 66	52.2 67.8	38.38 30.81	10 4	8.3 8.2	154 257	564 649
3-18	Grab C III 0.5 3.5 6.5 9m	54.6	17.1	6.3	12.0	1.08 1.88 2.23 1.95 1.86 1.99	0.51 1.30 0.95 1.01 1.06 1.09	11.7 21.6 14.8 18.6 18.2 20.1	9.8 2.2 9.8 10.6 10.0 9.9	33.8 53.3 37.0 37.7 38.4 37.2	37 108 38 33 35 35	893 321 1274 1393 1040 807	6845 18714 6631 5941 5702 5035	4580 94 4328 4888 3856 4832	12318 19129 12233 12222 10598 10674	34 89 33 32 34 33	34 89 33 33 34 33	52.6 57.9 52.2 53.1 52.4 52.6	36.56 31.16 37.59 37.24 36.81 36.47	9 29 17 17 9 7	8.1 8.2 8.1 8.1 8.1 8.1	141 222 154 157 160 155	566 605 538 547 526 530
3-25	Grab C III			8.2	6.1	9.72 0.92	1.99 0.69	14.8 17.8	9.8 0.7	34.3 57.6	24 38	902 188	6131 20524	4788 170	11821 20882	24 38	24 38	52.2 66.9	34.97 31.40	12 17	8.3 8.3	143 240	521 649
4-2	Grab C III			9.0	2.0	1.72 1.33	0.64 1.00	14.0 19.3	9.5 0.9	32.9 44.4	33 86	712 412	6607 16904	4440 125	11759 17441	27 61	30 75	50.9 49.0	38.40 28.96	10 11	8.2 8.3	137 185	532 549
4-8	Grab C III			10.8	9.8	18.43 1.31	2.33 0.83	11.1 11.1	 1.4	37.0 36.5	40 64	679 212	6369 18714	4679 109	11727 19035	27 50	40 64	50.5 36.0	36.74 35.70	12 16	8.0 8.0	154 152	524 493
4-15	Grab C III			10.1	8.2	10.36 4.47	1.88 2.85	11.5 19.7	 1.1	31.0 54.2	124 180	1188 231	5536 19760	3172 128	9896 20119	27 83	71 83	50.7 63.8	37.11 37.98	17 10	8.3 8.3	129 226	538 639

APPENDIX 8. Continued

ANALYSES – INDIAN CREEK RESERVOIR

Date	Sample Type	Res. Depth	Secchi Disk	Temperature		Unfiltered Samples						0.45µ Millipore Filtered Samples											
				Water	Air	Susp. Solids	Vol. Susp. Solids	COD	DO	Inorg. C	Total Phos. as P	Nitrogen as N				Phosphorus as P		Ca	Cl⁻	Fe	pH	Alk. as $CaCO_3$	Cond. (10^{-6})
												Org.	NH_3	$NO_2 + NO_3$	Total	PO_4	Total						
		ft	ft	°C	°C	mg/l	mg/l	mg/l	mg/l	mg/l	µg/l	µg/l	µg/l	µg/l	µg/l	µg/l	µg/l	mg/l	mg/l	µg/l		mg/l	mhos
4-22	Grab C			13.1	9.2	6.44	1.71	14.6		31.2	30	1045	5964	4272	11281	23	26	49.5	37.32	12	8.2	130	535
	III					0.71	0.63	14.2	1.5	35.2	51	179	17666	128	17973	47	47	65.9	43.93	13	8.3	233	672
4-29	Grab C	57.0	10.7	11.2	10.0	1.82	1.15	15.6	9.8	31.2	28	750	6655	4468	11873	20	24	49.8	39.93	5	8.2	130	545
	III					1.66	0.75	13.0	0.3	56.6	52	188	24522	915	25625	49	56	64.0	43.88	6	8.2	236	649
	0.5			11.2		2.54	1.89	20.5	9.8	34.1	27	1079	6822	3911	11812	14	24	56.7	35.16	8	8.2	142	558
	3.5			10.8		4.06	2.55	19.0	10.2	37.0	27	750	6655	4580	11985	26	26	55.0	36.24	5	8.1	154	554
	6.5			10.3		1.58	1.48	14.5	9.2	37.2	26	817	6369	4288	11474	13	20	56.7	35.70	11	8.1	155	556
	9.5			10.1		3.00	1.58	16.7	9.4	33.1	28	798	5821	4468	11087	27	27	56.7	36.15	4	8.2	138	545
5-6	Grab C	57.0	20.0	13.8	14.5	0.94	0.66	14.9	9.6	31.9	38	893	6702	4468	12063	10	32	55.7	36.09	5	8.0	133	549
	III					0.69	0.49	16.0	2.4	58.1	87	179	16904	167	17250	74	77	69.0	38.16	16	8.1	242	610
	0.5			13.8		0.10	0.10	16.0	9.6	42.0	33	1221	6131	3886	11236	20	33	57.6	36.75	58	8.0	175	532
	3.5			13.0		3.11	1.89	18.2	9.9	37.7	33	798	7084	4300	12182	27	30	57.1	35.81	7	8.0	157	530
	6.5			12.8		3.10	1.86	17.1	10.7	36.7	37	760	6464	4468	11692	27	33	57.1	36.09	3	8.0	153	538
	9.5			12.5		8.28	2.88	18.6	9.6	38.4	34	650	6845			26	29	56.9	36.56	14	8.1	160	562
5-15	Grab C			14.2	14.9	18.23	2.82	15.0		32.6	123	1202	5865	3728	10775	24	64	56.7	39.53	10	8.3	136	496
	III					2.25	1.52	12.7	1.8	47.8	152	164	20810	60	21034	74	74	66.9	46.32	20	8.3	199	610
5-20	Grab C	57.4	10.5	13.0	10.1	2.70	2.13	18.6	8.6	37.2	17	898	4990	4512	10400	17	17	57.9	38.66	4	8.2	155	554
	III					0.49	0.49	9.1	2.6	59.8	40		19000	1110		38	39	77.1	38.38	18	8.3	249	713
	0.5			13.0		2.82	2.26	16.4	8.6	46.3	24	788	6370	4384	11542	23	24	60.2	36.15	<1	8.3	193	539
	3.5			12.9		3.01	2.51	15.6	8.2	41.8	25	845	6300	4300	11445	25	25	57.4	36.52	3	8.3	176	541
	6.5			12.2		4.24	3.46	16.4	7.9	39.4	25	612	6130	4272	11014	24	25	56.0	36.24	10	8.3	164	539
	9.5			12.0		4.02	3.19	17.5	8.6	39.1	26	883	5655	4440	10978	24	25	57.4	35.97	4	8.3	163	541
5-28	Grab C	57.4	9.1	15.7	13.5	4.70	4.58	17.2	11.0	35.8	117	1093	5179	3534	9806	80	115	57.8	37.76	4	8.4	146	513
	III					0.57	0.57	9.2	1.4	63.6	119	<1	24524	60	24584	117	119	69.1	29.81	11	8.3	265	661
	0.5			15.7		6.27	5.50	20.2	11.0	39.8	111	1069	6655	3311	11035	80	111	58.1	38.90	<1	8.4	166	515
	3.5			15.6		6.15	5.59	16.9	14.0	39.8	105	1069	6607	3074	10750	95	105	57.9	38.11	7	8.4	165	517
	6.5			15.6		4.67	4.26	14.7	11.3	38.2	94	1188	5512	3492	10192	77	92	58.1	37.94	2	8.4	159	498
	9.5			15.6		5.22	4.41	16.2	11.0	38.9	111	683	5631	3465	9779	108	111	57.4	36.89	3	8.4	162	515
6-3	Grab C	57.3	13.6	16.5	18.2	1.27	1.02	14.6	11.7	36.2	139	802	4703	4566	10071	66	129	56.9	37.37	<1	8.2	151	514
	III					3.05	1.99	14.2	1.5	62.9	379	64	20240	93	20397	279	287	70.0	30.96	16	8.2	262	661
	0.5			16.5		2.25	1.87	17.1	11.7	39.4	132	988	5393	4424	10805	80	117	60.0	37.11	5	8.2	164	515
	3.5			16.2		2.36	2.03	13.8	13.0	39.1	129	1169	5060	4300	10529	72	120	59.1	35.88	6	8.2	163	512
	6.5			16.0		2.19	1.91	15.3	13.5	39.1	123	1312	5155	4592	11059	70	108	59.7	35.79	7	8.2	163	506
	9.5			15.8		1.28	1.28	14.6	10.1	39.1	140	760	4917	4372	10049	76	122	59.5	35.26	2	8.2	163	495
6-10	Grab C			20.5	19.2	7.84	6.92	26.8	15.2	31.2	180	1078	3840	4872	9790	14	62	49.8	37.68	3	8.5	130	495
	III					0.92	0.85	20.0	1.5	60.6	790	413	21550	59	22022	698	698	69.1	36.94	4	8.2	250	689
6-17	Grab C		19.8	19.2	18.5	0.81	0.66	16.4	7.6	31.6	134	753	4988	4440	10181	84	117	55.2	40.77	6	8.3	131	488
	III					0.65	0.56	16.7	1.5	47.3	555	648	25250	94	25992	510	529	60.3	61.67	11	8.3	197	680
	0.5			19.2		1.62	1.33	17.8	7.6	34.6	138	1158	5738	4620	11516	95	132	54.8	40.24	12	8.4	144	504
	3.5			19.0		2.07	1.91	18.5	8.3	35.3	134	1153	4936	4552	10643	79	138	55.0	39.81	9	8.4	147	497
	6.5			18.8		1.35	1.33	19.6	7.8	35.0	135	1098	5463	4608	11169	83	114	54.5	40.51	9	8.4	145	506
	9.5			18.5		1.18	1.33	19.2	7.8	34.6	129	1298	4738	4440	10476	80	112	54.1	39.90	9	8.4	144	497
6-24	Grab C	56.8	19.5	19.0	24.3	0.62	0.64	13.2	9.4	32.9	160	1103	4963	4580	10646	105	136	54.8	44.79	43	8.3	137	492
	III					0.57	0.60	22.0	1.8	45.6	524	998	22460	100	23118	357	398	48.6	47.97	24	8.2	190	595
	0.5			19.0		1.31	1.21	16.0	9.4	36.1	199	1298	5013	4231	10542	105	137	56.3	40.54	15	8.3	142	506
	3.5			19.0		0.92	0.98	16.0	7.4	35.0	159	1348	3787	4400	9535	107	159	53.8	40.35	11	8.3	146	492
	6.5			18.9		0.87	0.86	12.8	7.9	34.8	162	1263	4038	4022	9323	108	160	54.3	40.03	10	8.3	145	492
	9.5			18.8		1.09	0.92	13.6	7.9	34.6	164	1133	4173	4120	9426	102	127	54.1	41.31	12	8.3	144	492

APPENDIX 8. Continued

ANALYSES – INDIAN CREEK RESERVOIR

Date	Sample Type	Res. Depth	Secchi Disk	Temperature		Unfiltered Samples						0.45µ Millipore Filtered Samples											
				Water	Air	Susp. Solids	Vol. Susp. Solids	COD	DO	Inorg. C	Total Phos. as P	Nitrogen as N				Phosphorus as P		Ca	Cl⁻	Fe	pH	Alk. as $CaCO_3$	Cond. (10^{-6})
												Org.	NH_3	$NO_2 + NO_3$	Total	PO_4	Total						
		ft	ft	°C	°C	mg/l	mg/l	mg/l	mg/l	mg/l	µg/l	µg/l	µg/l	µg/l	µg/l	µg/l	µg/l	mg/l	mg/l	µg/l		mg/l	mhos
7-1	Grab C	56.6	7.4	21.3	24.2	4.75	4.75	18.0	13.5	31.7	309	1358	4313	5484	11155	38	261	53.1	45.56	6	8.4	132	508
	III					0.32	0.32	22.3	1.1	47.3	752	733	28550	85	29368	677	748	50.7	45.75	6	8.3	197	605
	0.5			21.3		6.04	5.63	22.4	13.5	31.7	374	1318	3432	5152	9902	52	145	52.6	41.22	<1	8.6	132	497
	3.5			20.2		3.91	3.91	20.4	12.4	32.4	220	1548	3513	4972	10033	46	145	52.9	41.02	2	8.4	135	499
	6.5			19.5		2.20	2.20	19.6	10.3	32.6	231	1463	4513	4984	10960	101	183	52.9	41.12	7	8.6	136	497
	9.5			19.0		2.30	2.22	18.0	8.6	33.1	382	1358	3613	4928	9899	83	174	53.6	41.31	10	8.4	138	499
7-8	Grab C			18.0	13.0	9.70	5.38	24.2	10.3	29.3	143	1353	2788	5552	9693	32	76	52.9	44.56	<1	8.3	122	488
	III					0.62	0.56	25.8	0.7	47.8	467	763	37150	47	37960	396	420	43.4	45.98	16	8.0	199	599
7-15	Grab C			19.2	21.6	1.71	1.52	18.4	8.1	31.0	347	2013	2638	5428	10079	57	105	52.4	46.20	<1	8.4	129	490
	III					1.65	1.31	28.2	1.1	42.7	519	988	34190	66	35124	349	428	46.4	48.67	17	8.2	178	599
	0.5			19.2		2.33	2.21	18.8	8.1	29.5	131	993	2663	5512	9168	57	120	51.9	44.38	11	8.4	123	488
	3.5			19.1		3.13	2.97	22.9	8.3	29.8	123	1008	2888	5848	9744	57	116	52.8	39.83	<1	8.4	124	491
	6.5			19.0		2.13	2.13	18.4	7.8	30.0	117	1158	2738	5724	9620	59	110	52.1	39.92	2	8.4	125	490
	9.5			19.0		3.38	3.21	19.6	6.6	30.2	149	2553	2138	5848	10539	65	122	51.9	39.83	<1	8.4	126	490
7-22	Grab C	56.0	15.7	21.3	26.7	1.33	1.11	25.3	5.7	28.8	148	1273	2763	5568	9604	77	142	52.6	47.47	20	8.3	120	484
	III					1.53	1.03	28.9	0.4	38.4	260	923	25350	71	26344	102	191	60.0	86.00	11	8.2	160	682
	0.5			21.3		1.82	1.23	20.1	5.7	29.5	164	1528	2488	5960	9976	77	135	52.2	44.84	4	8.3	123	490
	3.5			20.8		1.88	1.57	20.1	5.6	29.0	148	1353	2438	5848	9639	78	133	52.9	44.23	7	8.3	121	484
	6.8			20.1		1.57	1.24	21.3	4.7	29.3	145	1513	2713	5820	10046	88	143	52.8	43.22	7	8.3	122	486
	9.0			19.9		1.81	1.47	25.2	3.6	29.3	151	1050	1988	5836	8882	89	151	52.8	43.62	6	8.3	122	486
7-29	Grab C	56.7	19.6	21.4	21.0	0.96	0.77	12.8	5.2	29.0	154	1268	2663	5404	9335	89	141	51.4	39.80	2	8.3	121	494
	III					1.29	0.91	21.2	1.0	46.8	365	693	32050	66	32809	99	176	48.8	44.39	10	8.2	195	587
	0.5			21.4		1.82	1.09	20.0	5.2	29.3	160	1428	3638	5444	10510	83	145	50.5	39.98	11	8.3	122	494
	3.5			21.3		1.29	1.07	15.2	4.8	29.8	176	1428	2288	5556	9272	87	176	51.6	37.04	4	8.3	124	494
	6.5			21.2		1.62	1.62	14.0	4.0	29.8	160	1323	3188	5556	10067	62	136	51.0	38.97	2	8.3	124	494
	9.5			21.2		2.35	1.58	14.0	3.3	29.3	160	1243	1988	5584	8815	86	153	51.9	39.80	6	8.3	122	494
8-4	Grab C	56.2	14.1	22.0	23.0	1.44	1.16	14.9	4.0	27.6	181	1063	3338	5428	9829	86	159	50.9	48.66	1	8.3	115	504
	III					1.25	0.69	22.9	0.2	38.2	261	618	25250	64	25732	161	207	53.1	51.23	9	8.3	159	546
	0.5			22.0		1.44	1.15	18.1	4.0	30.2	207	878	3263	5444	9585	98	162	50.7	46.65	6	8.4	126	504
	3.5			21.1		1.53	1.25	14.5	3.8	30.5	159	1186	3738	5484	10408	97	157	51.4	46.43	1	8.4	127	504
	6.5			20.8		1.37	1.03	14.5	3.8	30.5	205	1198	2713	5556	9467	97	165	51.2	46.88	16	8.4	127	504
	8.5			20.5		1.40	1.07	12.9	3.4	30.2	201	753	2088	5696	8537	92	174	51.0	43.64	11	8.4	126	504
8-12	Grab C			21.0	22.0	21.23	4.99	16.3	5.4	26.2	196	1008	1788	5724	8520	68	186	51.0	45.77	18	8.2	109	506
8-19	Grab C			20.5	19.5	28.71	10.75	29.6	3.4	27.1	197	1213	1358	5780	8381	47	99	48.4	50.41	<1	8.3	113	492
	III					1.23	0.92	40.7	1.5	44.9	667	868	28150	81	29899	438	666	44.5	51.22	7	8.3	187	612
8-26	Grab C	46.6	24.4	20.2	20.1	0.64	0.46	29.0	7.8	27.4	100	748	1613	5680	8041	51	93	50.3	50.92	35	8.3	114	518
	III					1.10	9.91	44.4	1.2	47.8	495	963	29050	73	30086	252	430	47.5	48.78	38	8.1	199	633
	0.5			20.2		2.54	1.13	35.1	7.8	27.0	102	613	1388	5528	7529	55	120	50.0	46.84	17	8.3	116	506
	3.5			20.0		1.60	1.05	33.9	7.6	27.1	117	803	1138	5888	7829	44	118	50.0	46.43	19	8.3	113	495
	6.5			19.5		1.92	1.13	30.2	7.9	27.1	84	1128	1188	5960	8276	42	98	49.5	45.31	13	8.3	113	495
9-4	Grab C	43.6	20.0	19.9		0.64	0.49	11.4	7.1	25.4	151	1083	1913	5793	8788	42	86	49.5	52.27	<1	8.2	106	525
	III					4.61	3.09	31.5	0.0	46.6	621	1068	29050	64	30182	174	279	54.5	57.88	26	8.2	194	649
	0.5			19.9		1.13	0.89	13.8	7.1	26.6	172	968	1388	5848	8184	40	106	48.8	48.04	4	8.2	111	536
	3.5			19.8		1.24	1.09	16.6	6.9	26.4	138	1308	1078	5708	8094	38	87	48.3	47.01	2	8.2	110	525
	5.0			19.8		1.25	1.25	13.8	7.5	25.9	145	813	1153	6112	8078	34	76	48.1	46.28	4	8.2	108	525

APPENDIX 8. Continued

ANALYSES – INDIAN CREEK RESERVOIR (Continued)

				Temperature		Unfiltered Samples						0.45μ Millipore Filtered Samples											
Date	Sample Type	Res. Depth	Secchi Disk	Water	Air	Susp. Solids	Vol. Susp. Solids	COD	DO	Inorg. C	Total Phos. as P	Nitrogen as N				Phosphorus as P		Ca	Cl⁻	Fe	pH	Alk. as $CaCO_3$	Cond. (10^{-6})
												Org.	NH_3	$NO_2 + NO_3$	Total	PO_4	Total						
		ft	ft	°C	°C	mg/l	mg/l	mg/l	mg/l	mg/l	μg/l	μg/l	μg/l	μg/l	μg/l	μg/l	μg/l	mg/l	mg/l	μg/l		mg/l	mhos
9-9	Grab C	43.5	21.1	20.1	19.5	1.26	1.05	15.2	7.8	25.7	111	1328	1213	5076	8617	66	98	48.1	48.67	3	8.2	107	509
	III					6.50	2.66	30.8	0.6	46.1	159	808	29050	55	29913	96	223	48.6	45.71	7	8.2	192	611
	0.5			20.1		1.81	1.48	15.6	7.8	25.9	115	763	1288	5988	8039	41	99	50.0	45.10	6	8.3	108	509
	3.5			19.5		1.96	1.88	15.2	7.9	26.6	163	1258	963	5848	8069	37	89	48.8	45.51	5	8.3	111	503
	6.5			19.2		1.53	1.39	31.2	8.3	25.0	101	1053	788	6268	8109	37	86	49.8	46.09	1	8.3	104	503
9-15	Grab C	43.5	20.8	18.6	16.5	0.64	0.58	16.7	7.4	26.6	128	1003	3188	5152	9343	80	141	48.3	51.55	6	8.1	111	517
	III					1.25	0.88	25.7	1.1	46.6	354	663	24050	73	24786	180	248	45.0	56.43	31	7.9	190	650
	0.5			18.6		1.54	1.26	17.8	7.4	26.6	120	1553	2413	5404	9370	71	113	48.6	50.48	7	8.1	111	512
	3.5			18.0		1.93	1.64	16.7	7.4	26.6	155	943	1163	5612	7718	61	105	50.2	51.66	2	8.1	111	489
	6.5			17.5		0.99	0.99	18.8	8.5	25.4	105	1073	1388	4996	7457	46	89	48.6	48.09	6	8.1	106	489
9-23	Grab C	42.0	11.0	18.7	17.0	0.88	0.64	32.4	7.2	26.2	111	1378	2238	3828	7444	62		47.6	51.93	15	8.3	109	498
	III					0.97	0.79	41.6	2.0	45.6	296	308	34950	67	35325	96	247	39.3	33.44	12	8.1	198	556
	0.5			18.7		2.82	1.76	33.6	7.2	26.2	123	1487	1913	5012	8412	54	100	48.6	51.42	25	8.2	109	508
	3.5			17.1		1.96	1.69	31.6	7.0	26.2	112	1655	1563	4996	8214	55	102	48.6	46.85	12	8.2	109	500
9-29	Grab C	39.5	11.8	17.0	17.5	0.65	0.54	11.51	7.3	26.4	174	1143	2513	5680	9336	39	100	47.4	75.39	7	8.1	110	510
	III					1.88	0.20	14.2	1.6	42.0	130	278	10075	335	10688	47	95	45.3	58.29	15	7.8	168	588
	0.5			17.0		2.11	0.36	15.9	7.3	26.4	111	1298	788	5840	7926	58	101	44.5	58.73	12	8.2	110	506
	3.5			16.8		2.14	0.70	15.5	7.3	26.2	114	1278	788	5840	7906	47	100	47.6	47.96	7	8.2	109	492
10-6	Grab C	40.0	18.0	15.2	11.3	0.95	0.86	14.5	7.1	25.9	101	1305	2357	5264	8926	61	101	47.8	49.64	14	8.2	108	513
	III					2.10	1.74	18.6	1.5	40.6	137	362	17363	92	17817	48	81	46.2	49.10	<1	8.2	169	582
	0.5			15.2		4.01	3.25	16.0	7.1	25.9	170	1271	1815	5708	8794	127	167	47.6	49.73	8	8.3	108	516
	3.5			15.2		4.97	4.17	17.6	6.9	25.4	96	1381	2206	5584	9251	46	97	46.9	46.49	14	8.3	106	506
	5.0			14.5		3.65	1.92	15.6	7.8	25.2	121	1457	1643	5600	8700	51	89	47.1	46.50	19	8.3	105	486
10-13	Grab C	40.0	17.8	14.4	14.9	17.42	2.00	22.8	7.5	24.2	126	910	7238	5404	13552	56	111	47.2	49.46	14	8.2	101	510
	III					1.57	0.87	13.5	1.2	39.4	133	190	31162	166	31498	52	95	44.3	42.17	3	8.1	166	583
	0.5			14.4		2.44	1.73	17.8	7.5	25.7	108	871	6476	6044	13391	56	92	47.4	46.49	10	8.3	107	517
	3.5			13.9		1.51	1.07	17.0	7.2	25.2	92	1095	8010	5904	15009	58	80	46.9	45.05	16	8.3	105	507
	5.0			13.0		2.04	0.87	14.7	8.5	25.0	90	643	7381	6016	14040	37	82	47.0	44.06	14	8.3	104	506

APPENDIX 9. MAXIMUM, MINIMUM, AND AVERAGE VALUES OF QUALITY FACTORS IN RECLAIMED WATER (COMPUTED FROM MONTHLY REPORTS BY THE SOUTH TAHOE PUBLIC UTILITY DISTRICT). (All values in mg/ℓ except Turbidity, pH and Coliform)

Date	BOD$_5$	COD	Susp. Solids	MBAS	Turbidity JTU	pH	Chlorine Residual Instantaneous	Colif. (mpn)	Nitrogen			Phosphate	Alkalinity	Hardness	Total Dissolved Solids	Chloride	Sulfate
									Ammonia	Nitrate	Nitrite						
1971 May	5.2^a	18.1	0	0.33	0.6	7.8	3.5	<2.0	23.8	0.60	0.37	0.29	363	170	350	26.0	23.0
	0.0^b	5.1	0	0.06	0.2	7.1	1.3	<2.0	16.1	0.00	0.00	0.08	193	126	260	22.0	14.0
	1.4^c	10.5	0	0.17	0.3		2.6	<2.0	19.7	0.20	0.09	0.18	226	155	294	24.0	17.9
June	4.3	16.5	0	0.31	0.7	7.7	4.0	<2.0	23.5	11.3	0.43	0.28	260	158	540	31.0	29.0
	0.0	3.8	0	0.01	0.2	7.0	1.1	<2.0	16.4	0.1	0.01	0.06	176	134	264	24.0	13.0
	1.1	13.5	0	0.10	0.36		2.6	<2.0	19.3	0.81	0.06	0.15	212	148	327	26.3	19.7
July	2.2	15.7	0	0.27	0.5	7.6	3.6	<2.0	30.4	7.5	0.17	0.99	258	154	348	33.0	21.0
	0.4	3.5	0	0.01	0.2	7.0	1.5	<2.0	18.9	0.0	0.01	0.15	176	130	286	23.0	14.0
	1.0	8.6	0	0.15	0.3		2.3	<2.0	26.3	1.7	0.04	0.30	219	142	316	27.0	16.8
August	2.6	20.1	0	0.17	0.5	8.5	5.6	<2.0	30.4	12.5	0.50	0.76	259	176	354	33	22.0
	0.4	3.3	0	0.01	0.0	7.8	0.7	<2.0	21.0	0.0	0.00	0.02	135	130	276	25	13.0
	1.1	8.1	0	0.11	0.3		2.2	<2.0	26.7	2.2	0.10	0.38	205	150	326	30	16.8
Sept	3.1	8.3	0	0.21	0.6	7.9	2.5	<2.0	29.0	19.8	0.28	0.25	318	168	376	33	26
	0.0	2.2	0	0.01	0.1	7.2	0.7	<2.0	28.7	0.0	0.01	0.06	112	136	252	28	14
	1.0	5.6	0	0.10	0.2		1.4	<2.0	24.7	2.2	0.08	0.14	216	148	331	30	19
Oct	5.8	10.8	0	0.24	0.3	7.8	2.7	<2.0	27.9	9.1	0.31	0.27	305	634	1166	46	27
	0.4	1.6	0	0.01	0.1	7.1	0.9	<2.0	19.1	0.1	0.02	0.04	175	132	244	15	13
	1.5	6.2	0	0.13	0.2		1.6	<2.0	23.0	1.1	0.13	0.13	216	194	375	29	16
Nov	3.3	9.6	0	0.27	0.5	7.5	3.1	2.2	25.7	1.8	0.30	0.28	249	220	468	99	21
	0.4	5.0	0	0.04	0.2	7.1	1.1	<2.0	17.7	0.2	0.01	0.05	167	164	280	27	13
	1.1	7.6	0	0.17	0.25		1.9	<2.0	22.3	0.9	0.1	[illegible]	217	164	342	46	17
Dec	4.0	21.9	0	1.10	1.5	8.1	1.9	<2.0	29.3	1.8	0.20	0.57	272	186	384	31	49
	0.6	4.3	0	0.07	0.2	7.2	0.9	<2.0	21.2	0.0	0.01	0.04	167	152	274	22	16
	1.2	11.5	0	0.22	0.6		1.4	<2.0	25.3	0.7	0.05	0.35	221	166	337	27	25
1972 Jan	2.2	17.2	0	0.23	0.5	8.2	4.6	240.0	28.2	0.7	0.30	0.42	265	184	414	30	25
	0.1	02.1	0	0.01	0.3	7.1	1.0	<2.0	18.5	0.0	0.01	0.30	201	150	310	26	16
	1.2	11.5	0	0.14	0.4		2.3		22.3	0.3	0.08	0.47	222	167	344	28	20
Feb	2.0	13.1	0	0.27	0.9	8.2	3.4	<2.0	39.7	0.0	0.01	0.74	372	204	508	33	29
	0.1	3.3	0	0.10	0.3	7.1	1.4	<2.0	18.6	0.9	0.08	0.09	259	168	312	25	13
	1.1	9.8	0	0.18	0.5		2.2		24.8	0.3	0.03	0.44	332	184	366	28	19
Mar	2.6	14.0	0	0.36	1.0	8.0	3.6	38.0	24.2	2.2	1.13	0.70	365	232	534	29	31
	0.3	2.4	0	0.05	0.3	7.0	0.4	<2.0	14.6	0.0	0.01	0.16	266	164	238	24	17
	1.4	7.9	0	0.15	0.5		1.6		18.0	0.5	0.22	0.39	305	205	368	26	23
Apr	1.6	20.1	0	0.50	0.6	8.0	8.7	8.8	15.5	11.0	0.12	0.71	296	300	770	33	30
	0.1	2.6	0	0.16	0.2	6.9	0.7	<2.0	5.6	4.2	0.02	0.09	185	166	200	19	17
	1.0	16.0	0	0.27	0.3		2.2		9.4	6.6	0.06	0.26	230	202	413	26	23
May	2.7	10.0	0	0.35	0.3	7.7	2.3	<2.0	25.0	18.6	0.52	0.25	285	196	717	33	24
	0.2	1.3	0	0.11	0.1	6.8	0.6	<2.0	2.8	0.2	0.01	0.07	154	138	180	19	13
	1.0	6.3	0	0.21	0.2		1.4	<2.0	8.5	10.2	0.17	0.16	220	172	330	28	20
June	1.5	11.3	0	0.70	0.4	7.6	2.8	<2.0	16.2	30.5	0.34	0.26	308	190	560	26	18
	0.2	2.2	0	0.07	0.1	6.7	0.6	<2.0	6.4	0.2	0.01	0.06	175	142	224	22	15
	0.7	5.5	0	0.20	0.2		1.5	<2.0	10.3	14.1	0.58	0.14	223	163	330	25	17
July	7.4	29.6	0	0.62	1.2	7.9	3.6	13.0	28.3	6.3	0.39	0.30	295	180	380	35	36
	[illegible]	8.0	0	0.16	0.3	7.0	0.4	<2.0	18.4	0.0	0.01	0.06	207	104	240	25	16
	1.8	15.1	0	0.35	0.6		1.6		23.4	1.1	0.08	0.19	257	158	302	30	24
Aug	3.2	28.7	0	0.45	0.5	8.6	2.2	<2.0	35.1	0.9	0.27	0.41	329	166	416	36	36
	0.0	4.5	0	0.11	0.2	6.9	0.6	<2.0	22.1	0.0	0.01	0.04	187	110	120	28	15
	0.7	11.5	0	0.21	0.4		1.2	<2.0	26.7	0.2	0.05	0.20	263	146	286	32	20

^{a}High
^{b}Low
^{c}Average

APPENDIX 9. Continued

Date	BOD_5	COD	Susp. Solids	MBAS	Turbidity JTU	pH	Chlorine Residual Instantaneous	Colif. (mpn)	Nitrogen			Phosphate	Alkalinity	Hardness	Total Dissolved	Chloride	Sulfate
									Ammonia	Nitrate	Nitrite						
Sept	2.9[a]	19.5	0	0.23	0.6	7.8	3.5	<2.0	33.0	00.9	0.38	0.38	305	154	390	32	24
	0.0[b]	5.4	0	0.00	0.3	7.0	1.0	<2.0	19.0	00.0	0.00	0.13	248	122	160	27	11
	1.0[c]	10.1	0	0.13	0.3		2.0	<2.0	26.0	00.4	0.17	0.22	263	141	291	30	18
Oct	4.1	18.0	0	1.20	0.6	7.4	2.3	8.0	30.0	15.0	0.36	0.41	330	196	430	39	41
	0.0	1.6	0	0.03	0.2	7.0	0.6	<2.0	28.0	00.0	0.03	0.14	253	146	304	30	12
	1.1	7.9	0	0.20	0.3		1.2		24.7	00.8	0.16	0.24	309	170	335	32	21
Nov	8.0	17.5	0	0.52	2.5	7.3	7.1	38.0	32.0	00.6	0.52	0.29	375	198	380	34	40
	0.4	3.4	0	0.17	0.3	6.8	0.2	<2.0	6.0	00.0	0.01	0.12	190	170	190	30	10
	2.1	11.3	0	0.40	0.6		1.6		19.8	00.3	0.10	0.19	257	185	286	32	26
Dec	3.9	19.5	0	0.46	0.5	7.5	1.8	<2.0	19.0	00.7	0.40	0.35	275	--	410	35	20
	0.1	2.9	0	0.17	0.3	6.8	0.4	<2.0	9.0	00.2	0.03	0.15	226	--	136	23	14
	1.3	8.4	0	0.28	0.3		1.1	<2.0	14.4	00.4	0.17	0.25	249	--	295	29	17
1971																	
Jan	4.4	9.0	0	0.51	1.0	7.6	1.4	38.0	25.0	00.6	0.19	0.22	380	--	412	37	29
	0.6	0.5	0	0.25	0.2	7.2	0.2	<2.0	10.0	00.1	0.01	0.13	254	--	206	22	17
	2.2	4.3	0	0.39	0.5		0.7		18.0	00.4	0.09	0.17	277	--	339	29	20
Feb	2.4	16.8	0	0.07	0.4	7.5	3.5	<2.0	27.0	04.7	0.28	0.26	314	--	416	42	16
	0.1	7.1	0	0.04	0.2	6.9	0.5	<2.0	14.0	00.0	0.01	0.16	291	--	182	34	14
	1.2	10.6	0	0.05	0.3	--	1.9	<2.0	19.0	00.8	0.10	0.21	288	--	313	38	15
Mar	3.1	15.4	0	0.23	0.3	7.3	5.7	<2.0	34.0	00.7	0.06	0.55	297	--	330	64	18
	0.1	0.0	0	0.12	0.1	6.3	0.8	<2.0	15.0	00.0	0.01	0.13	180	--	200	36	12
	1.1	7.8	0	0.15	0.2	--	2.17	<2.0	22.3	00.2	0.02	0.31	244	--	260	53	15
Apr	3.1	15.2	0	0.15	0.5	7.1	3.0	<2.0	25.0	00.3	0.12	0.43	300	--	360	87	33
	0.1	2.6	0	0.01	0.2	6.8	0.2	<2.0	16.0	00.0	0.01	0.22	70	--	214	18	13
	1.5	11.1	0	0.07	0.4	--	1.8	<2.0	22.0	00.2	0.05	0.30	227	--	285	41	20
May	1.1	18.9	0	0.10	0.7	7.4	2.7	<2.0	20.0	01.0	0.38	0.55	318	--	426	38	24
	0.0	11.2	0	0.06	0.3	6.9	1.2	<2.0	16.0	00.0	0.03	0.09	249	--	196	8	15
	0.5	13.7	0	0.08	0.5	--	1.7	<2.0	19.0	00.4	0.16	0.25	283	--	344	25	18
June	2.2	18.2	0	0.135	0.6	7.4	2.8	<2.0	20.0	0.28	0.33	0.26	281	--	576	40.5	20.4
	0.3	8.5	0	0.015	0.3	6.8	0.9	<2.0	7.0	0.00	0.01	0.09	220	--	200	26.0	12.0
	0.98	12.0	0	0.073	0.4	--	1.4	<2.0	14.8	0.09	0.10	0.16	249	--	401	32.6	17.7
July	3.3	15.6	0	0.340	0.5	7.6	2.8	9.2	25.0	0.05	0.34	0.29	264	--	378	39.6	36.1
	0.3	5.1	0	0.011	0.3	6.8	1.1	<2.0	19.0	0.02	0.05	0.14	226	--	226	15.2	15.3
	2.0	13.3	0	0.131	0.4	--	1.4	2.6	22.3	0.04	0.19	0.20	247	--	293	30.4	19.3
Aug	5.2	19.7	0	0.62	0.8	7.6	3.6	2.3	25.0	0.12	0.49	0.46	319	--	384	50.0	60.0
	0.2	8.4	0	0.27	0.3	6.8	1.2	<2.0	12.0	0.01	0.01	0.11	187	--	80	35.5	16.4
	2.2	14.8	0	0.38	0.4	--	2.0	--	21.0	0.06	0.11	0.22	276	--	210	36.0	25.6
Sept	7.2	21.6	0	0.07	0.7	7.9	2.8	2.2	29.0	0.02	0.16	0.20	415	--	360	49.4	53.6
	0.9	11.2	0	0.04	0.4	6.8	0.6	<2.0	19.0	0.02	0.01	0.04	251	--	130	34.0	15.2
	2.9	17.3	0	0.05	0.5	--	1.8	--	22.0	0.02	0.05	0.12	397	--	297	39.6	22.9
Oct	2.2	23.1	0	0.82	0.5	7.3	4.0	<2.0	28.0	0.10	0.01	0.07	350	--	--	39.6	28.8
	0.4	8.4	0	0.47	0.2	6.9	1.2	<2.0	19.0	0.01	0.01	0.04	285	--	--	32.1	13.8
	1.5	14.8	0	0.64	0.3	--	2.1	<2.0	24.0	0.05	0.01	0.06	316	--	--	35.8	17.7
Nov	2.6	22.4	0	0.16	0.5	7.5	2.3	<2.0	26.0	0.10	0.02	0.38	339	--	422	41.4	16.4
	0.5	6.3	0	0.06	0.2	6.7	1.1	<2.0	19.0	0.01	0.01	0.07	268	--	38	28.3	15.2
	1.2	13.8	0	0.09	0.3	--	1.5	--	22.2	0.04	0.01	0.24	303	--	297	34.5	15.4
Dec	3.5	30.1	0	0.18	1.2	7.7	2.7	8.8	30.0	0.03	0.09	0.23	348	--	488	41.0	19.6
	0.8	2.7	0	0.06	0.3	6.9	0.6	<2.0	22.0	0.01	0.01	0.13	272	--	86	30.2	15.2
	1.8	13.1	0	0.11	0.5	--	1.7	--	25.7	0.02	0.03	0.19	302	--	311	36.9	16.7
1972	8.1	40.2	0	0.90	1.2	7.7	3.0	<2.0	40.0	0.20	0.02	0.80	352	--	400	42.4	27.6
Jan	0.5	9.6	0	0.36	0.5	7.2	1.2	<2.0	19.0	0.01	0.01	0.22	253	--	176	34.9	13.2
	4.1	20.5	0	0.53	0.8	--	2.3	--	25.7	0.10	0.02	0.49	315	--	301	39.3	17.3
Feb	4.1	30.0	0	0.30	1.0	7.3	4.4	<2.0	38.0	0.23	0.26	0.41	410	--	430	48.2	23.2
	0.4	6.3	0	0.07	0.4	6.8	1.2	<2.0	19.0	0.01	0.01	0.19	297	--	312	31.0	15.3
	1.7	13.2	0	0.19	0.9	--	2.6	--	25.2	0.10	0.06	0.29	342	--	375	37.8	16.8
Mar	5.3	35.2	0	0.29	0.8	7.6	4.4	<2.0	36.0	0.32	0.12	0.57	381	--	330	56.6	19.6
	0.2	8.8	0	0.15	0.1	6.8	0.5	<2.0	19.0	0.02	0.01	0.34	281	--	246	28.3	14.4
	2.3	17.9	0	0.23	0.5	--	2.2	--	28.3	0.12	0.09	0.41	318	--	294	34.1	16.7

[a] High
[b] Low
[c] Average

APPENDIX 10

IONIC ANALYSES FOR METALS IN RECLAIMED WATER

South Tahoe Public Utility District - 1971

List Taken from Sept. 24, 1971 Report (15)

(Tests by Battelle - NW Research)

		Concentration in mg/l	
Element		Reclaimed Water	Maximum Allowable USPHS-DWS
Arsenic	less than	0.005	0.05
Chromium^{+6}	less than	0.0005	0.05
Copper		0.0116	1.0
Iron	less than	0.0003	0.3
Manganese		0.002	0.05
Selenium	less than	0.0005	0.01
Silver		0.0004	0.05
Zinc	less than	0.005	5.0
Bromine		0.065	--
Uranium		0.0015	--
Cobalt		0.00022	--
Cesium		0.000006	--
Mercury	less than	0.0005	--
Rubidium		0.010	--
Scandium		0.000001	--
Antimony		0.00044	--

APPENDIX 11. PHYTOPLANKTON COUNTS OF SAMPLES COLLECTED AT STATION C, ICR

	1972															1973																		1974			
Date of Sampling	5/30	6/19	6/26	7/16	7/31	8/14	8/28	9/11	9/18	9/25	10/9	10/16	10/30	11/13	11/27	3/26	4/23	5/7	5/21	6/4	6/18	7/2	7/17	8/20	8/27	9/10	9/17	10/1	10/15	10/29	11/13	11/26	12/6	1/16	2/6	3/6	3/8
Total Count, Organisms/ml	272	178	413	626	2007	826	1545	858	Scan	198	967	4,260	681	683	609	2,360	463	890	840	2481	772	840	626	1053	623	377	324	381	369	1637	Scan	376	Scan	Scan	Scan	Scan	300
(Division, Chlorophyta (Smith)																																					
Bacillariophyceae (Diatoms)													x																								
Diatom sp.		x	x 89[a]	x	x	x	x	x	x	x	x			x	x 75	x 64	x	x	x	x	x	x	x	x	x 75	x	x	x 39	x	x	x	x 603	x	x	x	x	x
Navicula	x		x	x	x	x		x	x	x	x	x	x	x	x		x	x	x	x	x	x		x	x	x	x	x	x	x	x	x	x	x	x	x	x
Synedra	x	x	x		x	x	x	x		x	x	x	x	x				x				x			x		x		x		x		x		x	x	x
Nitzschia	x	x			x		x		x	x	x	x	x	x	x	x		x							x	x		x	x		x	x	x				x
Cocconeis				x	x		x	x	x	x		x	x	x	x		x				x			x	x	x	x	x	x	x	x	x	x	x	x		x
Melosira												x																									
Diatoma		x			x	x						x							x						x				x		x						
Surirella				x			x					x																	x	x	x	x	x		x		
Tabellaria						x	x								x																	x			x		
Frustulia					x				x																												
Pinnularia							x	x	x			x			x	x												x			x						x
Gomphonema				x	x		x			x	x	x	x		x					x				x	x		x	x		x	x	x	x				x
Gomphoneis												x		x	x									x		x											
Eunotia	x																																				
Cyclotella					x																																
Achnanthes						x	x			x	x														x												
Mastogloia										x				x																							
Cymatopleura										x																					x						x
Asterionella				x	x						x					x																			x		
Meridion					x		x	x	x	x	x	x	x	x	x	x		x	x		x	x		x	x	x	x	x	x	x	x	x	x	x	x	x	
Stephanodiscus			x																																		
Cymbella																					x														x		x
Stauroneis												x																									
Fragilaria																		x																			
Schroederia																					x 66	x 520	x 36	x	x	x	x	x									
Diatoms: Approx. % Total Count	32		37	16	1	12	1	12		28	27%	5	17	34	31	4	7	6	1.7	1	4	3	3	8	33	38	25	39	31	4		23					34
Chlorophyta (Smith)																																					
Chlorella	x 160	x 53	x 120	x 71	x	x	x 224	x 107	x	x	x	x	x	x 153	x	x	x	x	x		x	x	x	x	x	x	x	x	x	x	x	x					
Oocystis	x		x	x	x	x		x		x		x		x	x	x	x	x	x		x			x				x		x	x						
Cosmarium	x				x	x		x		x	x		x			x			x	x		x	x							x				x		x	x
Closterium								x		x			x			x		x	x	x														x			
Ankistrodesmus	x 80		x	x			x	x				x												x											x		
Spirogyra			x		x																														x		
Coelastrum													x	x																							
Gloeocystis				x	x	x		x		x	x	x	x	x	x						x																
Protococcus			x	x	x	x			x																												
(Vegetative cells)	x	x	x	x 231	x	x	x	x		x 39	x	x 2867	x	x 96	x 110	x	x 174	x 473	x 167	x	x 89	x 93	x 121	x 427	x 153	x 53	x 107	x 102	x 96	x 171	x	x 139		x	x	x	x 197
Botryococcus			x	x						x																											
Schizochlamys	x																																				
Mougeotia																		x																			
Microspora																																			x		
Ulothrix																															x						
Chrysophyta (Smith)																																					
Chlorobotrys												x																						x			x
Monocilia												x												x													
Chrysomonadida (Kudo)																																					
Chrysococcus		x	x [illegible]	x	x 637	x 274	x	x 292	x	x 140	x 276	x	x 57	x	x 89	x	x 78	x 71	x	x	x	x	x	x	x		x	x 32	x	x		x		x			x
Synura					x																										x						
Cryptomonadida (Kudo)																																					
Chilomonas sp.			x				x				x	x																									
Cryptomonas sp.		x			x 132	x 103	x 840	x	x 931	x 89	x 157	x 262	x 238	x	x	x 437	x 71	x		x	x	x 78	x 117	x 388	x 139	x	x 75	x	x 32	x 1281	x	x 63				x	x
Phytomonadida (Kudo)																																					
Chlamydomonas sp.							x	x					x	x	x	x		x 33	x 153	x 1866	x 269	x	x	x										x	x		
Volvocidae (Family)	x									x						x 253					x			x													
Volvox			x	x								x											x											x			
Polytoma							x																														
Eudorina																					x		x	x	x		x			x							
Spermatozopsis sp.												x																									
Nephroselmis												x																									
Bodo sp.							x				x	x				x																		x		x	
Euglenoidida (Kudo)																																					
Euglena sp.	x		x				x																						x								
Euglena acus					x		x			x																				x							
Phacus sp.																											x										
Trachelomonas sp.	x	x	x		x	x	x 206	x	x	x	x	x	x	x	x 78	x 1494	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x		x 60
T. crebea	x											x																									
Anisonema sp.							x	x				x	x		x	x			x	x	x	x			x	x 282			x	x	x	x		x	x	x	x
Ciliata (Kudo)																																					
Holophrya sp.							x	x							x	x	x	x	x	x		x		x	x												
Oxytricha sp.							x			x						x			x		x									x	x	x	x	x			
Colpidium							x			x			x									x							x			x					
Pleuronema							x																														
Uronema							x																														
Chilodonella							x																														
Spathidium							x																														
Cinetochilum												x																									

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[a] Number of organisms per ml.

APPENDIX 12

ALGAL BIOASSAYS OF ICR AND STPUD EFFLUENT: COUNTS, pH AND SUSPENDED SOLIDS MEASUREMENTS.

Date of Sample	Sample Type	Conc of Sample	Duration of Growth 1-Day Counts CELLS/mm^3	3-Day Counts CELLS/mm^3	5-Day Counts CELLS/mm^3	Composite pH at Day 5 (Suspended Solids)	$\hat{\mu}_b$ Days^{-1}
5/17/71	C	1 A	62.8	129.6	158.0	7.4	.362
		B	68.4	144.4	168.8	---	.374
		C	69.2	138.0	166.4		.345
		10 A	67.6	152.0	182.0	7.4	.405
		B	62.0	146.4	174.0		.430
		C	68.8	144.4	177.6		.371
		100 A	69.2	112.4	175.6	8.3	.243
		B	62.4	126.4	182.4		.353
		C	65.2	126.8	176.4		.333
	III	1 A	71.2	143.6	216.8	7.4	.351
		B	64.8	144.4	212.0		.401
		C	61.2	133.2	209.2		.389
		10 A	54.4	92.0	178.0	7.5	.330
		B	53.2	98.0	170.8		.305
		C	56.0	95.6	167.2		.280
		100 A	52.8	50.0	50.8	8.1	.00794
		B	49.6	49.6	50.4		.00800
		C	52.0	48.8	51.2		.024
6/2/71	C	1 A	47.6	70.8	88.0	7.2	.199
		B	46.4	58.4	67.2		.115
		C	52.8	70.8	83.6		.147
		10 A	43.2	92.4	138.0	7.7	.380
		B	45.2	96.4	133.2		.379
		C	48.8	113.6	142.0		.422
		100 A	39.2	151.6	203.6	7.6	.676
		B	43.6	156.8	203.2		.640
		C	54.4	159.2	214.0		.537
	III	1 A	45.2	102.4	233.6	7.5	.412
		B	44.0	73.6	199.6		.499
		C	46.4	104.0	229.6		.404
		10 A	52.8	71.2	90.8	7.4	.149
		B	50.0	77.2	102.8		.217
		C	48.4	63.2	83.2		.137
		100 A	43.6	41.2	53.2	77	.128
		B	41.6	39.2	51.2		.134
		C	38.8	41.6	53.2		

APPENDIX 12. Continued

Date of Sample	Sample Type	Conc of Sample	Duration of Growth			Composite pH at Day 5 (Suspended Solids)	$\hat{\mu}_b$ Days^{-1}
			1-Day Counts CELLS/mm^3	3-Day Counts CELLS/mm^3	5-Day Counts CELLS/mm^3		
6/14/71	C	1 A	55.2	70.8	78.4	7.9	
		B	57.6	78.0	90.4		.152
		C	60.4	82.0	104.8		.188
		10 A	53.2	72.8	94.4	72.	.130
		B	53.6	76.0	98.0		.175
		C	57.2	87.6	106.8		.196
		100 A	54.8	104.0	129.2	8.3	.320
		B	56.4	101.6	130.4		.294
		C	72.4	108.8	136.0		
	III	1 A	48.4	61.6	90.0	7.3	.190
		B	49.6	68.8	104.0		.207
		C	45.6	59.2	88.8		.203
		10 A	44.0	43.6	43.6	8.0	0
		B	44.0	42.8	43.6		.00926
		C	43.6	42.4	41.6		(-)
		100 A	45.2	43.2	42.8	8.4	(-)
		B	42.8	43.6	43.6		.00926
		C	43.6	42.8	43.6		.00926
6/21/71	C	1 A	60.0	84.4	97.6	7.8	.171
		B	64.0	91.2	100.0		.177
		C	61.2	85.6	92.0		.168
		10 A	55.2	72.0	82.8	7.9	.133
		B	59.6	79.2	80.0		.142
		C	60.4	76.8	84.0		.120
		100 A	50.0	60.4	64.4	8.3	.0945
		B	52.4	66.0	74.4		.115
		C	57.2	65.6	66.0		.0685
	III	1 A	62.0	86.8	134.0	8.1	.217
		B	61.2	73.6	118.4		.238
		C	63.2	83.2	119.6		.181
		10 A	55.2	66.4	74.0	8.0	.0924
		B	54.0	62.8	72.0		.0681
		C	57.6	64.4	80.4		.111
		100 A	52.8	51.2	52.0	8.5	.00775
		B	52.0	51.6	52.0		.00385
		C	49.6	50.8	50.8		.0313
7/7/71	C	1 A	52.0	73.6	89.2		.174
		B	52.8	74.4	96.4	*	.171
		C	53.6	74.4	97.2		.164

APPENDIX 12. Continued

Date of Sample	Sample Type	Conc of Sample	1-Day Counts CELLS/mm^3	3-Day Counts CELLS/mm^3	5-Day Counts CELLS/mm^3	Composite pH at (Suspended Solids)	$\hat{\mu}_b$ Days^{-1}
7/7/71		10 A	51.6	76.4	113.6		.198
		B	51.2	72.4	111.6	*	.216
		C	50.4	78.4	118.4		.221
		100 A	46.8	63.2	116.4		.305
		B	48.8	64.0	116.4	*	.299
		C	47.6	64.4	116.4		.296
	III	1 A	52.4	57.6	*	Coulter counter was not operating	.0473
		B	52.8	63.2	*		.0899
		C	54.8	66.8	*		.0990
		10 A	52.0	158.4	*		.557
		B	52.0	195.6			.662
		C	51.2	192.8			.663
		100 A	48.4	63.2			.133
		B	47.2	62.8	*		.143
		C	48.4	72.0			.199
7/26/71	C	1 A	98.4	65.6	94.8	7.4	.184
		B	76.0	46.0	42.4		(-)
		C	97.6	42.0	37.6		(-)
		10 A	38.0	64.4	51.2	7.3	.264
		B	38.4	66.8	53.6		.277
		C	36.0	53.2	50.0		.195
		100 A	50.0	126.8	332.8	8.1	.482
		B	52.0	136.4	337.6		.482
		C	54.4	137.2	333.6		.463
	III	1 A	39.2	80.8	128.0	7.4	.362
		B	37.6	77.6	114.0		.362
		C	37.2	70.8	112.8		.322
		10 A	——	——	——	7.4	——
		B	30.8	18.0	86.4		.784
		C	25.6	13.2	62.8		.780
		100 A	29.6	16.4	16.8	8.5	.0120
		B	28.8	14.4	15.6		.0400
		C	27.6	14.0	16.4		.0791
8/9/71	C	100 A	32.4	9.6	144.4	7.8	1.36
		B	——	——	——	(2.94)^{ss}	——
		C	33.6	10.0	206.4		1.51

APPENDIX 12. Continued

			Duration of Growth				
Date of Sample	Sample Type	Conc of Sample	1-Day Counts CELLS/mm^3	3-Day Counts CELLS/mm^3	5-Day Counts CELLS/mm^3	Composite pH at (Suspended Solids)	$\hat{\mu}_b$ Days^{-1}
8/9/71	III	100 A	49.6	37.6	18.4	8.4	(-)
		B	51.6	33.6	13.2	(1.53)	(-)
		C	52.8	42.0	12.8		(-)
9/7/71	C	100 A	50.8	142.0	176.4	7.2	.514
		B	45.2	99.6	124.8	(5.46	.395
		C	46.8	104.0	130.8		.399
	III	100 A	38.8	29.2	38.4	8.0	.137
		B	36.4	27.6	32.8	(1.46)	.0863
		C	38.4	29.6	34.8		.0809
9/14/71	C	100 A	55.2	163.6	240.4	7.4	—
		B	56.0	144.8	200.4	(9.83)	.475
		C	62.8	227.6	328.0		.644
	III	100 A	42.0	36.8	40.0	8.1	.0417
		B	43.6	36.0	42.8	(1.81)	.0865
		C	37.6	35.6	38.8		.0430
9/27/71	C	100 A	56.8	214.8	289.2	8.1	.665
		B	56.0	300.8	489.0	(9.89)	.841
		C	60.4	334.8	526.0		.856
	III	100 A	43.2	46.0	44.8	8.0	.0314
		B	42.8	39.2	37.6	(1.50)	(-)
		C	45.2	39.6	38.8		(-)
10/4/71	C	100 A	60.8	212.0	282.8	7.6	.624
		B	59.2	210.8	272.0	8.37	.635
		C	56.8	210.0	267.2		.654
	III	100 A	44.0	41.6	41.6	7.9	0
		B	46.0	43.6		1.34	.0311
		C	44.4	42.0	36.8		(-)
10/11/71	C	100 A	62.0	203.2	250.4	7.4	.594
		B	59.6	173.6	205.2	7.97	.535
		C	61.6	179.6	217.2		.535
	III	100 A	43.6	42.8	44.8	7.9	.0228
		B	42.4	35.2	36.0	1.40	.0112
		C	39.6	34.0	31.2		(-)
10/18/71	C	100 A	57.2	155.2	165.2	7.5	.499
		B	54.4	144.8	141.2	7.70	.489
		C	55.2	154.4	152.4		.514

APPENDIX 12. Continued

Date of Sample	Sample Type	Conc of Sample	Duration of Growth			Composite pH at (Suspended Solids)	$\hat{\mu}$ Days^{-1}
			1-Day Counts CELLS/mm^3	3-Day Counts CELLS/mm^3	5-Day Counts CELLS/mm^3		
10/18/71	III	100 A	46.4	50.8	36.0	8.0	.0453
		B	42.8	46.0	44.8	3.26	.0361
		C	44.8	45.2	45.2		.00444
11/1/71	C	100 A	52.0	77.6	78.4	7.5	.200
		B	50.8	77.6	87.2	2.86	.212
		C	50.0	80.8	83.6		.240
	III	100 A	48.4	51.2	50.0	7.9	.0281
		B	47.2	48.8	49.2	1.42	.0167
		C	48.4	52.0	49.6		.0359
11/8/71	C	100 A	50.4	59.6	66.8	7.5	.0838
		B	49.6	53.2	55.6	2.33	.0350
		C	52.4	55.6	56.4		.0296
	III	100 A	48.8	50.0	49.6	8.1	.0121
		B	47.2	51.2	50.4	1.08	.0407
		C	46.0	49.6	48.8		.0377
11/15/71	C	100 A	52.0	98.0	157.2	7.8	.317
		B	52.8	80.8	126.0	5.24	.222
		C	49.2	74.8	112.4		.209
	III	100 A	48.4	51.6	54.8	8.3	.0320
		B	55.6	52.8	54.4	2.11	.0149
		C	51.6	54.8	52.8		.0301
3/27/73	C	100 A	56.4	57.6	62.0	8.1	.0368
		B	60.0	123.2	180.4	6.30	.360
		C	50.0	104.8	144.0		.370
	III	100 A	50.0	50.0	50.4	8.6	.00398
		B	49.6	50.8	50.0	2.73	.0120
		C	52.0	53.2	50.4		.0114
4/3/72	C	100 A	50.4	73.2	90.8	8.7	.187
		B	51.6	62.0	66.8	(4.73)	.0918
		C	47.2	88.8	128.0		.316
	III	100 A	49.6	53.2	50.0	8.7	.0350
		B	52.4	54.8	52.0	(4.43)	.0224
		C	50.8	52.8	50.4		
4/10/72	C	100 A	51.2	58.4	61.6	8.6	.0267
		B	53.2	61.6	70.0	(3.65)	.0733
		C	54.4	64.4	70.4		.0844

APPENDIX 12. Continued

			Duration of Growth				
Date of Sample	Sample Type	Conc of Sample	1-Day Counts CELLS/mm^3	3-Day Counts CELLS/mm^3	5-Day Counts CELLS/mm^3	Composite pH at (Suspended Solids)	$\hat{\mu}_b$ Days^{-1}
4/10/72	III	100 A	56.0	58.4	52.8	8.7	.0210
		B	56.4	58.8	52.8	(6.92)	.0208
		C	52.0	59.6	54.4		.0682
4/17/72	C	100 A	55.6	67.2	69.2	8.0	.0947
		B	56.8	62.4	60.8	(2.91)	.0470
		C	57.6	69.2	67.2		.0917
	III	100 A	52.8	75.2	50.0	8.5	.177
		B	50.0	51.2	50.0	(2.30)	.0119
		C	50.0	52.4	49.2		.0234
4/25	C	100 A	55.6	87.2	112.8	8.2	.225
		B	53.6	58.8	60.0	(2.74)	.0463
		C	54.8	68.8	84.4		.114
	III	100 A	49.6	60.8	51.6	8.4	.102
		B	52.0	49.2	47.6	(3.41)	(-)
		C	53.2	55.6	50.0		.0221
5/1	C	100 A	55.6	58.8	58.8	8.2	.0280
		B	55.6	58.4	60.8	(2.84)	.0246
		C	54.4	74.8	101.6		.159
	III	100 A	51.2	52.0	52.0	8.3	.00775
		B	51.6	54.4	50.0	(1.22)	.0264
		C	50.8	54.4	50.8		.0342
5/8	C	100 A	54.8	58.4	62.0	8.6	.0318
		B	56.4	80.8	122.0	(3.33)	.206
		C	55.2	64.8	83.6		.127
	III	100 A	52.4	52.8	52.0	8.7	.00380
		B	50.8	52.4	47.6	(1.31)	.0155
		C	52.0	50.8	46.4		(-)
5/15	C	100 A	51.6	66.4	76.4	8.6	.126
		B	49.2	53.6	56.8	(2.05)	.0428
		C	52.0	68.4	80.8		.137
	III	100 A	46.0	49.2	48.4	8.6	.0336
		B	42.8	45.2	47.2	(0.95)	.0273
		C	48.8	46.4	49.2		.0293
5/22	C	100 A	51.6	54.8	54.8	8.5	0
		B	51.6	55.2	55.2	(1.81)	.0337
		C	50.8	60.0	69.2		.0832

APPENDIX 12. Continued

Date of Sample	Sample Type	Conc of Sample	Duration of Growth 1-Day Counts CELLS/mm^3	 3-Day Counts CELLS/mm^3	 5-Day Counts CELLS/mm^3	Composite pH at (Suspended Solids)	$\hat{\mu}_b$ Days^{-1}
5/22	III	100 A	47.6	46.0	45.6	8.6	(-)
		B	39.6	42.0	45.2	(1.62)	.0367
		C	43.6	46.0	44.8		.0268
5/31	C	100 A	51.2	52.0	53.6	8.5	.0152
		B	54.4	60.8	68.0	(2.00)	.0560
		C	58.4	66.4	74.4		.0642
	III	100 A	46.4	45.2	44.4	8.7	(-)
		B	45.2	45.6	43.6	(1.62)	.00441
		C	44.0	43.6	44.8		
6/1	C	100 A	46.0	61.6	63.2	8.5	.146
		B	45.2	61.2	62.0	(2.22)	.152
		C	46.0	61.2	62.8		.143
	III	100 A	52.8	46.0	46.8	—	.00862
		B	53.2	44.4	49.2	(1.72)	.0513
		C	53.2	45.2	46.8		.0174
6/12	C	100 A	48.4	49.6	56.8	8.2	.0678
		B	49.2	62.8	72.8	(2.00)	.122
		C	49.2	50.4	56.8		.0598
	III	100 A	44.8	45.2	44.8	8.6	.00444
		B	51.2	45.6	52.8	(1.29)	.0733
		C	48.4	47.2	51.2		.0407
6/19	C	100 A	51.6	57.6	65.6	8.5	.0650
		B	47.2	55.6	67.6	(2.22)	.0977
		C	47.2	49.2	50.8		.0207
	III	100 A	46.4	44.4	49.2	8.7	.0513
		B	45.2	44.4	45.6	(1.57)	.0133
		C	44.8	44.0	45.2		.0135
6/26	C	100 A	49.6	64.8	87.2	8.3	.148
		B	46.4	50.8	56.0	(2.84)	.0487
		C	49.2	65.6	90.0		.158
	III	100 A	44.8	48.4	48.8	8.7	.0386
		B	52.8	46.8	48.8	(2.78)	.0209
		C	48.8	44.8	47.6		.0303
7/5	C	100 A	53.2	74.4	97.2	8.4	.168
		B	52.0	76.0	104.0	(3.80)	.190
		C	53.2	68.4	87.6		.126

APPENDIX 12. Continued

			Duration of Growth				
Date of Sample	Sample Type	Conc of Sample	1-Day Counts CELLS/mm^3	3-Day Counts CELLS/mm^3	5-Day Counts CELLS/mm^3	Composite pH at (Suspended Solids)	$\hat{\mu}_b$ Days^{-1}
7/5	III	100 A	50.0	38.4	44.8	8.7	.0771
		B	47.2	36.8	45.6	(1.16)	.107
		C	49.2	36.4	44.0		.0948
7/10	C	100 A	52.8	104.0	162.4	8.5	.339
		B	57.6	124.0	186.4	(5.56)	.383
		C	52.8	107.2	150.0		.354
	III	100 A	44.4	46.4	47.6	8.6	.0333
		B	44.4	42.4	46.4	(1.39)	.0451
		C	48.4	45.6	47.6		.0215
7/17	C	100 A	47.6	——	——	8.3	——
		B	44.0	72.8	104.8	(3.14)	.252
		C	47.6	73.2	104.0		.215
	III	100 A	41.6	34.0	34.8	8.7	.0116
		B	39.2	33.2	32.4	(0.97)	(-)
		C	39.6	34.0	32.4		(-)
7/25	C	100 A	46.8	90.0	120.0	8.4	.327
		B	42.4	——	——	3.83	
		C	43.2	82.0	120.0		.320
	III	100 A	44.0	38.8	38.8	8.7	0
		B	42.4	34.4	35.2	1.67	.0115
		C	43.6	39.6	38.0		(-)
7/31	C	100 A	44.0	44.0	45.6	8.3	.0179
		B	42.8	44.0	46.4	5.54	.0266
		C	45.2	98.4	137.2		.389
	III	100 A	42.4	36.0	41.6	8.7	.0723
		B	42.0	37.6	38.0	1.68	.00529
		C	42.8	37.6	39.6		.0259
8/8	C	100 A	52.0	——	——	8.3	——
		B	46.4	85.6	109.6	4.17	.306
		C	45.6	104.0	164.8		.412
	III	100 A	43.6	37.2	39.6	8.6	.0313
		B	44.0	38.0	43.6	2.03	.0687
		C	41.2	34.0	41.6		.101
8/14	C	100 A	——	——	——	8.4	——
		B	62.0	158.0	238.0	5.86	.468
		C	61.6	170.8	252.4		.510
	III	100 A	45.6	45.2	47.2	8.6	.0216
		B	42.8	35.2	44.0	2.31	.112
		C	46.0	37.2	43.2		.0748

APPENDIX 12. Continued

			Duration of Growth				
Date of Sample	Sample Type	Conc of Sample	1-Day Counts CELLS/mm^3	3-Day Counts CELLS/mm^3	5-Day Counts CELLS/mm^3	Composite pH at (Suspended Solids)	$\hat{\mu}_b$ Days^{-1}
8/21	C	100 A	——	——	——	8.4	——
		B	60.8	178.0	456.0	18.23	.537
		C	64.8	222.4	534.0		.617
	III	100 A	45.6	48.4	49.6	8.6	.0298
		B	46.0	44.8	49.2	2.22	.0468
		C	47.6	46.0	46.0		0
8/28	C	100 A	51.6	101.6	152.4	8.5	.339
		B	58.8	90.0	118.0	8.11	.213
		C	53.6	74.4	397.6		.825
	III	100 A	46.0	50.8	52.8	8.7	.0496
		B	44.0	49.6	47.6	2.08	.0599
		C	43.6	44.8	44.0		.0136
9/5	C	100 A	54.4	170.4	345.0	8.6	.571
		B	53.6	227.6	588.0	15.83	.723
		C	64.0	233.6	546.0		.647
	III	100 A	50.0	52.0	67.2	8.6	.128
		B	49.6	60.8	78.0	3.06	.125
		C	50.4	46.4	57.2		.105
9/11	C	100 A	60.8	264.0	540.0	8.7	.734
		B	62.8	254.4	547.0	19.26	.699
		C	64.0	245.2	529.0		.672
	III	100 A	47.2	49.2	57.6	8.7	.0788
		B	49.2	49.2	62.4	2.47	.119
		C	49.2	48.4	53.2		——
9/18	C	100 A	68.4	173.6	314.0	8.5	.466
		B	67.6	212.0	406.0	13.46	.571
		C	74.8	166.4	294.0		.400
	III	100 A	53.2	77.2	170.4	8.8	.396
		B	53.2	72.0	155.6	7.03	.385
		C	56.0	95.6	206.0		.384
9/25	C	100 A	51.6	87.2	133.6	8.2	.262
		B	50.8	80.8	128.0	4.64	.232
		C	53.2	91.2	141.2		.269
	III	100 A	48.4	46.4	73.6	8.7	.231
		B	48.8	45.6	68.8	2.00	.206
		C	49.2	46.4	65.2		.170

APPENDIX 12. Continued

Date of Sample	Sample Type	Conc of Sample	Duration of Growth			Composite pH at (Suspended Solids)	$\hat{\mu}_b$ Days^{-1}
			1-Day Counts CELLS/mm^3	3-Day Counts CELLS/mm^3	5-Day Counts CELLS/mm^3		
10/2	C	100 A	52.0	108.8	151.6	8.1	.369
		B	53.2	93.2	125.2	6.22	.280
		C	55.6	102.4	146.8		.305
	III	100 A	49.6	44.0	49.2	8.6	.0559
		B	49.6	43.6	50.4	2.46	.0725
		C	47.2	43.2	47.2		.0443
10/9	C	100 A	57.2	56.4	56.8	8.1	.00353
		B	55.6	69.2	77.2	3.67	.109
		C	54.8	79.2	79.2		.184
	III	100 A	47.6	42.0	45.6	8.6	.0411
		B	46.8	41.6	44.8	1.05	.0371
		C	52.0	38.8	48.4		.111
10/18	C	100 A	52.0	108.8	122.8	8.2	.369
		B	51.2	121.6	133.2	6.71	.432
		C	50.8	136.8	155.6		.495
	III	100 A	44.8	46.4	49.2	8.7	.0293
		B	45.2	48.4	50.4	3.11	.0342
		C	46.8	45.2	46.0		.00877
10/20	C	100 A	50.4	66.4	71.2	8.3	.138
		B	50.4	62.0	65.6	3.67	.104
		C	50.8	63.2	65.2		.109
	III	100 A	47.6	65.2	75.2	8.7	.157
		B	46.4	64.4	74.8	3.65	.164
		C	47.2	62.0	71.6		.136
10/30	C	100 A	53.2	176.4	205.6	8.4	.599
		B	56.0	176.4	203.6	8.28	.574
		C	58.4	167.6	199.6		.527
	III	100 A	49.6	70.0	80.8	8.7	.172
		B	50.0	66.4	78.8	3.65	.142
		C	50.8	62.8	64.8		.106
11/6	C	100 A	54.8	195.2	240.4	8.5	.635
		B	54.4	181.2	223.6	(9.23)	.602
		C	56.8	154.4	188.4		.500
	III	100 A	46.4	41.2	42.4	8.6	.0144
		B	47.6	43.6	42.0	(2.56)	(-)
		C	45.6	42.4	39.2		(-)

APPENDIX 12. Continued

Date of Sample	Sample Type	Conc of Sample	Duration of Growth			Composite pH at (Suspended Solids)	$\hat{\mu}_b$ Days^{-1}
			1-Day Counts CELLS/mm^3	3-Day Counts CELLS/mm^3	5-Day Counts CELLS/mm^3		
11/13	C	100 A	56.0	130.4	222.0	8.6	.423
		B	55.2	120.0	190.8	(8.82)	.388
		C	55.6	120.4	201.2		.386
	III	100 A	48.8	56.8	57.2	8.7	.0759
		B	50.0	49.6	49.6	(2.67)	0
		C	49.6	48.4	48.8		.00412
11/20	C	100 A	55.2	164.8	289.2	8.7	.547
		B	55.2	173.6	273.2	(10.84)	.573
		C	52.4	129.2	225.6		.451
	III	100 A	50.4	61.2	57.6	8.7	.0971
		B	48.4	51.2	50.4	(3.03)	.0281
		C	49.6	52.8	48.4		.0313
11/27	C	100 A	54.4	155.6	291.2	8.7	.525
		B	52.8	148.8	269.6	(11.81)	.518
		C	56.4	156.0	272.0		.509
	III	100 A	51.3	54.4	20.8	8.6	.0293
		B	48.8	48.4	29.6	(2.64)	(-)
		C	49.2	46.4	46.0		(-)
12/5	C	100 A	43.6	149.6	418.8	8.4	.616
		B	42.4	140.8	355.6	(13.02)	.600
		C	45.6	142.0	339.6		.568
	III	100 A	32.4	33.6	43.2	8.7	.126
		B	32.4	28.8	39.2	(0.92)	.154
		C	32.4	31.6	35.2		.0539
12/11	C	100 A	45.2	144.0	349.6	8.6	.579
		B	45.2	131.2	303.2	(9.08)	.533
		C	44.0	103.2	190.4		.426
	III	100 A	36.4	63.2	90.8	8.7	.276
		B	33.2	62.0	94.0	(2.78)	.312
		C	36.4	58.4	86.4		.236
12/26	C	100 A	52.4	296.8	899.0	8.8	.867
		B	53.6	298.8	929.0	(33.09)	.859
		C	53.6	272.0	846.0		.812
	III	100 A	—	—	—		—
		B	—	—	—	—	—
		C	—	—	—		—

APPENDIX 12. Continued

Date of Sample	Sample Type	Conc of Sample	Duration of Growth			Composite pH at (Suspended Solids)	$\hat{\mu}_b$ Days $^{-1}$
			1-Day Counts CELLS/mm^3	3-Day Counts CELLS/mm^3	5-Day Counts CELLS/mm^3		
1973							
1/2/73	C	100 A	43.2	116.0	——	8.7	.494
		B	46.8	182.0	648.0	(21.68)	.679
		C	50.4	193.2	707.0		.672
	III	100 A	37.6	38.4	50.8	8.7	.140
		B	42.0	37.6	54.4	(3.06)	.185
		C	38.4	30.8	45.6		.196
1/8/73	C	100 A	47.2	168.8	513.0	8.7	.637
		B	49.2	176.8	512.0	(23.14)	.640
		C	48.4	160.4	436.0		.599
	III	100 A	36.0	39.2	60.4	8.7	.216
		B	35.2	31.6	43.2	(4.00)	.156
		C	36.4	34.0	50.0		——
1/15/73	C	100 A	49.2	168.8	374.8	8.8	.616
		B	54.8	182.4	387.6	(17.24)	.601
		C	56.0	210.4	669.0		.662
	III	100 A	50.0	68.8	97.6	8.6	.175
		B	50.0	69.2	100.4	(5.03)	.186
		C	52.4	71.2	94.8		.153
1/22/73	C	100 A	54.8	209.2	499.0	8.9	.670
		B	55.6	228.4	672.0	(19.94)	.706
		C	52.8	209.6	493.0		.689
	III	100 A	50.0	78.8	110.8	8.8	.227
		B	51.2	79.6	105.2	(18.68)	.221
		C	49.2	78.0	98.0		.230
1/29	C	100 A	55.2	240.8	711.0	8.9	.737
		B	55.6	250.8	817.0	(30.43)	.753
		C	56.0	244.8	812.0		.738
	III	100 A	53.6	56.4	68.4	8.7	.0965
		B	52.8	52.4	56.0	(2.66)	.0332
		C	52.8	51.6	54.8		.0301
2/5	C	100 A	53.2	209.6	398.8	8.8	.686
		B	52.4	197.2	303.6	(15.37)	.663
		C	51.2	157.2	227.2		.561
	III	100 A	50.0	51.6	56.4	8.8	.0445
		B	50.4	51.2	53.6	(2.46)	.0229
		C	49.6	48.8	50.0		.0121

APPENDIX 12. Continued

Date of Sample	Sample Type	Conc of Sample	Duration of Growth 1-Day Counts CELLS/mm^3	3-Day Counts CELLS/mm^3	5-Day Counts CELLS/mm^3	Composite pH at (Suspended Solids)	$\hat{\mu}_b$ Days^{-1}
2/13	C	100 A	56.8	198.0	337.0	8.4	.625
		B	62.0	234.0	438.0	(15.00)	.664
		C	61.6	244.8	453.0		.690
	III	100 A	52.0	53.2	56.8	8.7	.0327
		B	52.8	52.0	52.8	(2.84)	.00763
		C	52.4	51.2	55.2		.0376
2/20	C	100 A	63.2	250.8	478.0	8.8	.689
		B	63.2	264.4	560.0	(24.11)	.716
		C	62.0	274.0	627.0		.743
	III	100 A	56.8	55.6	66.8	8.7	.0918
		B	54.4	52.0	56.8	(3.69)	.0441
		C	53.6	46.0	53.2		.0727
2/26	C	100 A	64.0	238.0	509.0	8.8	.657
		B	64.0	296.8	674.0	(23.85)	.767
		C	64.0	249.2	546.0		.680
	III	100 A	48.8	45.6	51.6	8.7	.0618
		B	48.4	46.0	49.2	(2.97)	.0336
		C	46.8	42.8	45.6		.0317
3/5	C	100 A	59.2	204.8	392.0	8.7	.621
		B	64.4	227.2	399.0	(14.46)	.630
		C	63.2	171.6	301.0		.499
	III	100 A	54.8	53.2	63.2	8.7	.0861
		B	48.4	46.4	55.6	(3.11)	.0904
		C	48.4	45.2	50.8		—
3/12	C	100 A	64.4	151.6	298.4	7.7	.427
		B	63.2	139.2	252.0	(7.71)	.395
		C	62.8	152.4	329.6		.443
	III	100 A	53.2	46.8	56.4	8.5	.0933
		B	53.2	45.2	54.8	(2.46)	.0963
		C	50.4	42.8	50.0		.0777
3/19	C	100 A	64.8	181.2	396.0	8.6	.514
		B	60.4	195.2	546.0	(13.97)	.587
		C	64.4	195.6	516.0		.555
	III	100 A	53.6	46.0	56.0	8.6	.0984
		B	51.6	45.2	50.4	(2.19)	.0544
		C	54.4	45.6	51.6		.0618

APPENDIX 12. Continued

Date of Sample	Sample	Conc of Sample		Duration of Growth			Composite pH at (Suspended Solids)	$\hat{\mu}_b$ Days^{-1}
				1-Day Counts CELLS/mm^3	3-Day Counts CELLS/mm^3	5-Day Counts CELLS/mm^3		
3/26	C	100	A	61.6	225.2	507.0	8.5	.648
			B	67.2	266.8	600.0	(16.14)	.689
			C	68.4	250.0	566.0		.648
	III	100	A	53.6	56.4	63.2	8.5	.0569
			B	55.6	53.6	61.2	(3.42)	.0663
			C	54.8	54.4	64.0		.0813
4/3	C	100	A	65.6	120.0	157.6	8.6	.302
			B	66.4	105.2	148.8	(7.94)	.230
			C	67.6	160.4	209.6		.432
	III	100	A	57.2	56.4	60.0	8.6	.0309
			B	57.6	57.2	61.6	(5.03)	.0371
			C	58.8	53.6	61.2		.0663
4/9	C	100	A	62.0	144.4	228.8	8.3	.423
			B	65.2	159.2	240.0	(11.14)	.446
			C	63.2	186.4	252.4		.541
	III	100	A	46.8	31.2	39.6	8.4	.119
			B	50.8	31.2	34.0	(3.19)	.0430
			C	45.6	25.6	28.4		.0519
4/16	C	100	A	72.8	299.2	425.0	8.5	.707
			B	68.4	292.4	416.0	(17.16)	.726
			C	72.0	318.4	434.0		.743
	III	100	A	44.8	44.4	42.0	8.5	(-)
			B	45.6	35.6	37.2	(3.09)	.0220
			C	43.2	38.8	36.8		(-)
4/23	C	100	A	76.8	347.6	501.0	8.5	.757
			B	76.8	380.4	543.0	(20.0)	.800
			C	78.0	385.6	541.0		.799
	III	100	A	45.2	51.6	50.0	8.6	.0662
			B	44.4	45.6	42.8	(2.36)	.0133
			C	44.8	39.2	39.6		.00508
4/30	C	100	A	67.6	238.4	361.0	8.5	.630
			B	66.4	286.0	489.0	(12.39)	.730
			C	66.8	216.0	337.0		.587
	III	100	A	56.8	48.8	44.4	8.6	(-)
			B	50.8	53.2	45.2	(2.05)	.0231
			C	43.2	37.2	39.2		——

APPENDIX 12. Continued

Date of Sample	Sample Type	Conc of Sample	Duration of Growth			Composite pH at (Suspended Solids)	$\hat{\mu}_b$ Days^{-1}
			1-Day Counts CELLS/mm^3	3-Day Counts CELLS/mm^3	5-Day Counts CELLS/mm^3		
5/7	C	100 A	53.2	196.4	363.2	7.9	.653
		B	55.6	217.2	398.4	(12.92)	.681
		C	56.4	214.0	398.8		.667
	III	100 A	——	——	——		——
		B	——	——	——		——
		C	——	——	——		——
5/14	C	100 A	52.0	216.8	384.0	8.6	.714
		B	57.2	238.0	426.4	(12.78)	.713
		C	55.6	159.2	308.8		.526
	III	100 A	34.8	35.6	38.8	8.7	.0430
		B	34.4	33.6	28.0	(2.32)	(-)
		C	35.2	35.2	31.6		0
5/21	C	100 A	52.8	187.6	342.4	8.7	.634
		B	52.8	188.4	370.8	(14.00)	.636
		C	50.4	170.4	308.4		.609
	III	100 A	32.8	28.0	32.0	8.7	.0668
		B	32.8	23.6	29.2	(3.47)	.106
		C	33.2	26.0	27.6		.0299
5/28	C	100 A	58.8	268.8	587.0	8.7	.760
		B	56.4	252.4	543.0	(18.33)	.749
		C	53.6	204.8	407.0		.670
	III	100 A	31.2	26.0	28.0	8.7	.0371
		B	31.2	21.6	24.4	(3.38)	.0609
		C	33.6	22.0	24.0		.0435
6/4	C	100 A	50.0	123.2	207.6	8.2	.451
		B	52.4	120.4	192.0	(8.80)	.416
		C	52.4	109.2	179.2		.367
	III	100 A	42.4	39.6	39.6	8.6	.146
		B	42.4	35.6	32.8	(2.78)	(-)
		C	41.2	32.8	25.2		(-)
6/11	C	100 A	57.2	162.8	238.4	8.3	.523
		B	53.2	139.6	216.0	(7.73)	.482
		C	50.4	114.0	173.6		.408
	III	100 A	38.8	34.0	36.8	8.6	.0396
		B	37.6	33.6	34.4	(2.00)	.0118
		C	38.0	32.8	32.4		.00155

APPENDIX 12. Continued

			Duration of Growth				
Date of Sample	Sample Type	Conc of Sample	1-Day Counts CELLS/mm^3	3-Day Counts CELLS/mm^3	5-Day Counts CELLS/mm^3	Composite pH at (Suspended Solids)	$\hat{\mu}_b$ Days^{-1}
6/18	C	100 A	62.4	211.6	348.0	8.4	.611
		B	59.6	260.4	477.0	(11.13)	.737
		C	58.8	245.2	435.0		.714
	III	100 A	47.6	35.2	44.8	8.6	.121
		B	46.0	44.4	57.2	(3.54)	.127
		C	45.6	29.2	34.8		.0877
6/26	C	100 A	62.8	248.4	540.0	8.4	.688
		B	60.4	244.8	553.0	(15.66)	.700
		C	60.8	222.0	493.0		.648
	III	100 A	37.2	40.0	34.0	8.6	.0363
		B	37.2	31.2	31.6	(2.53)	.00637
		C	38.4	27.2	28.4		.0216
7/2	C	100 A	—	—	—	8.4	—
		B	45.6	88.0	136.8	(20.37)	.329
		C	50.8	87.6	146.9		.272
	III	100 A	38.8	37.6	44.4	8.6	.0831
		B	37.6	35.6	44.0	(2.26)	.113
		C	36.4	36.0	40.0		
7/9	C	100 A	53.6	114.8	209.6	8.5	.381
		B	50.8	109.2	187.6	(8.69)	.383
		C	53.2	113.2	196.8		.378
	III	100 A	37.6	36.8	45.2	8.6	.103
		B	36.4	38.4	42.0	(1.36)	.0448
		C	37.2	32.4	42.4		.134
7/16	C	100 A	55.2	140.0	237.6	8.5	.465
		B	52.4	132.4	193.2	(5.49)	.463
		C	55.2	126.8	186.8		.416
	III	100 A	37.2	36.0	38.4	8.6	.0323
		B	37.2	32.8	38.8	(1.50)	.0840
		C	36.0	32.8	37.6		.0683
7/23	C	100 A	55.6	136.4	218.8	8.6	.449
		B	54.8	131.2	228.8	(8.11)	.437
		C	56.4	145.2	233.2		.473
	III	100 A	—	—	—	—	—
		B	—	—	—	—	—
		C	—	—	—		—

APPENDIX 12. Continued

Date of Sample	Sample Type	Conc of Sample		Duration of Growth 1-Day Counts CELLS/mm^3	3-Day Counts CELLS/mm^3	5-Day Counts CELLS/mm^3	Composite pH at (Suspended Solids)	$\hat{\mu}_b$ Days^{-1}
8/6	C	100	A	55.6	171.2	355.2	8.6	.562
			B	52.4	157.6	237.2	(9.86)	.551
			C	53.6	190.4	291.2		.634
	III	100	A	44.4	53.2	42.4	8.6	.0904
			B	42.0	46.8	38.8	(2.84)	.0541
			C	44.0	51.2	38.4		.0758
8/13	C	100	A	54.4	157.6	219.6	8.5	.532
			B	50.8	139.6	212.4	(8.22)	.505
			C	50.8	130.4	197.6		.471
	III	100	A	41.6	48.4	51.2	8.6	.0757
			B	38.8	38.8	36.8	(2.57)	0
			C	42.0	41.6	42.8		.0142
8/20	C	100	A	78.0	142.0	237.6	8.4	.300
			B	78.0	142.4	244.0	(9.09)	.301
			C	80.4	192.0	333.6		.435
	III	100	A	48.4	53.6	66.0	8.6	.104
			B	57.2	54.8	62.0	(2.78)	.0617
			C	54.8	54.8	60.8		.0519
8/27	C	100	A	80.0	156.8	230.4	8.4	.336
			B	84.4	157.2	270.4	(6.11)	.311
			C	78.4	149.2	256.4		.322
	III	100	A	53.6	48.8	54.4	8.6	.0543
			B	50.4	46.8	50.4	(2.00)	.0371
			C	52.4	47.2	47.2		0
9/4	C	100	A	90.8	148.8	212.8	8.5	.247
			B	84.0	167.2	269.2	(7.46)	.344
			C	84.0	152.0	226.4		.297
	III	100	A	56.8	57.6	71.2	8.7	.106
			B	54.4	52.0	68.0	(2.97)	.134
			C	51.2	59.6	67.2		.0760
9/10	C	100	A	88.8	178.0	275.6	8.4	.348
			B	82.0	141.2	235.2	(7.86)	.272
			C	84.4	143.6	259.2		.295
	III	100	A	53.6	64.8	77.6	8.6	.0949
			B	51.6	62.0	71.6	(2.92)	.0918
			C	52.4	68.4	174.0		.133

APPENDIX 12. Continued

			Duration of Growth				
Date of Sample	Sample Type	Conc of Sample	1-Day Counts CELLS/mm^3	3-Day Counts CELLS/mm^3	5-Day Counts CELLS/mm^3	Composite pH at (Suspended Solids)	$\hat{\mu}_b$ Days^{-1}
9/16	C	100 A	70.0	65.2	69.2	7.7	.0298
		B	61.6	59.6	68.4	(1.74)	.0689
		C	66.8	65.2	77.6		.0871
	III	100 A	54.8	48.8	51.6	8.0	.0279
		B	54.8	46.0	49.2	(2.16)	.0336
		C	54.8	46.0	46.4		.00433
9/24	C	100 A	60.4	51.6	56.8	7.9	.0480
		B	62.0	48.4	53.6	(1.31)	.0510
		C	61.2	48.4	57.2		.0835
	III	100 A	52.0	42.4	42.4	8.0	0
		B	48.4	36.8	36.8	(2.06)	0
		C	52.4	33.6	33.2		(-)
10/1	C	100 A	60.4	47.6	52.4	7.9	.0480
		B	60.8	49.2	53.2	(2.14)	.0391
		C	62.4	56.8	63.2		.0534
	III	100 A	55.2	32.8	31.2	8.0	(-)
		B	50.8	36.4	37.2	(1.61)	.0109
		C	54.4	24.0	24.0		0
10/8	C	100 A	66.0	93.2	92.8	7.9	.173
		B	67.6	101.2	103.2	(2.79)	.202
		C	66.0	99.2	96.8		.204
	III	100 A	58.8	39.2	43.6	8.0	.0532
		B	54.8	35.2	36.0	(1.82)	.0112
		C	54.8	33.2	30.8		(-)
10/15	C	100 A	57.6	64.0	92.4	8.1	.184
		B	55.2	53.2	72.0	(3.59)	.151
		C	57.2	60.4	72.4		.0906
	III	100 A	52.8	44.4	50.0	8.6	.0594
		B	50.4	45.6	47.2	(1.46)	.0172
		C	50.0	45.6	46.0		.00437
10/22	C	100 A	56.8	57.6	60.8	8.2	.0270
		B	56.4	60.0	61.2	(1.31)	.0309
		C	56.0	59.6	58.8		.0312
	III	100 A	50.8	43.2	42.4	8.7	(-)
		B	50.4	44.4	41.2	(1.86)	(-)
		C	51.2	42.8	42.6		(-)

APPENDIX 12. Continued

Date of Sample	Sample Type	Conc of Sample	Duration of Growth 1-Day Counts CELLS/mm^3	Duration of Growth 3-Day Counts CELLS/mm^3	Duration of Growth 5-Day Counts CELLS/mm^3	Composite pH at (Suspended Solids)	$\hat{\mu}_b$ Days^{-1}
10/29	C	100 A	56.4	68.8	108.8	8.4	.299
		B	56.0	70.4	111.6	(2.71)	.230
		C	59.2	71.2	114.4		.237
	III	100 A	50.0	46.0	72.0	8.7	.224
		B	49.2	47.6	70.0	(1.86)	.193
		C	52.4	41.6	70.8		.266
11/6	C	100 A	56.4	82.0	130.4	8.4	.232
		B	57.6	79.6	128.4	(1.03)	.239
		C	54.8	72.8	121.2		.255
	III	100 A	48.4	45.6	72.0	8.7	.228
		B	52.8	43.2	64.0	(1.92)	.197
		C	47.2	38.8	58.8		.208
11/13	C	100 A	90.0	170.0	230.4	8.2	.318
		B	92.0	175.2	238.8	(7.51)	.322
		C	93.2	172.8	219.2		.309
	III	100 A	65.6	103.6	124.8	8.6	.228
		B	68.0	96.4	121.6	(4.69)	.174
		C	68.4	95.6	116.8		
11/19	C	100 A	88.0	170.0	244.8	8.4	.329
		B	85.2	157.2	215.2	(10.31)	.306
		C	90.0	168.4	242.8		.313
	III	100 A	66.0	87.6	84.0	8.7	.142
		B	62.4	70.8	77.2	(3.47)	.0631
		C	62.0	68.4	79.6		.0758
11/26	C	100 A	93.6	302.0	660.0	8.5	.586
		B	—	—	—	(15.00)	—
		C	96.0	270.8	555.0		.519
	III	100 A	66.8	94.0	123.6	8.7	.171
		B	65.6	76.8	102.8	(5.25)	.146
		C	65.6	82.8	110.8		.146
12/4	C	100 A	128.4	659.0	1066.0	9.2	.818
		B	126.0	646.0	1014.0	(42.90)	.817
		C	128.0	581.0	1005.0		.756
	III	100 A					—
		B		No Sample			—
		C					—

APPENDIX 12. Continued

Date of Sample	Sample Type	Conc of Sample	Duration of Growth			Composite pH (Suspended Solids)	$\hat{\mu}_b$ Days^{-1}
			1-Day Counts CELLS/mm^3	3-Day Counts CELLS/mm^3	5-Day Counts CELLS/mm^3		
12/17	C	100 A	70.8	198.4	384.0	8.5	.515
		B	76.8	272.4	689.0	(22.30)	.633
		C	78.8	318.0	836.0		.698
	III	100 A	—	—	—	8.7	—
		B	46.4	49.6	45.2	(3.20)	.0333
		C	47.6	46.8	49.2		.0250
12/26	C	100 A	75.2	246.8	673.0	8.8	.594
		B	80.8	236.4	571.0	(23.6)	.537
		C	77.6	238.4	584.0		.561
	III	100 A	46.8	47.6	48.4	8.7	.00847
		B	46.0	43.2	42.4	(2.84)	(-)
		C	45.6	44.0	45.6		.0179
1/8/74	C	100 A				—	—
		B				—	—
		C					—
	III	100 A	63.2	90.0	714.0	8.8	1.04
		B	66.0	102.4	383.0	(35.26)	.660
		C	68.0	100.4	386.0		.673
1/14	C	100 A	78.4	199.6	362.0	8.9	.467
		B	82.8	302.4	753.0	(28.97)	.648
		C	79.6	350.0	877.0		.740
	III	100 A	51.6	66.0	150.4	8.9	.412
		B	51.2	66.4	129.6	(7.94)	.334
		C	53.2	70.8	167.6		.431
1/21	C	100 A	54.8	226.4	619.0	8.8	.709
		B	59.6	274.8	722.0	(20.51)	.764
		C	55.6	247.6	572.0		.747
	III	100 A	42.0	50.4	45.6	8.7	.0912
		B	42.4	49.2	39.6	(2.14)	.0744
		C	41.2	45.6	37.6		.0507
1/28	C	100 A	55.2	218.8	554.0	8.7	.689
		B	61.6	234.8	449.0	(17.08)	.669
		C	58.4	211.6	508.0		.644
	III	100 A	43.6	47.6	42.8	8.7	.0439
		B	44.0	46.0	37.6	(2.65)	.0222
		C	42.8	45.6	38.0		.0317

APPENDIX 12. Continued

Date of Sample	Sample Type	Conc of Sample	Duration of Growth			Composite pH at (Suspended Solids)	$\hat{\mu}_b$ Days^{-1}
			1-Day Counts CELLS/mm^3	3-Day Counts CELLS/mm^3	5-Day Counts CELLS/mm^3		
2/4	C	100 A	51.6	175.6	313.6	8.7	.612
		B	51.2	167.2	271.6	(15.49)	.592
		C	57.2	197.6	376.8		.620
	III	100 A	46.0	46.0	41.6	8.7	0
		B	43.6	44.8	47.2	(2.29)	.0261
		C	42.4	44.8	38.4		.0275
2/11	C	100 A	68.0	305.6	720.0	8.6	.751
		B	66.0	295.2	668.0	(23.37)	.749
		C	63.2	298.4	583.0		.776
	III	100 A	44.4	42.0	32.8	8.6	(-)
		B	44.0	36.8	34.0	(3.97)	(-)
		C	42.8	42.0	39.6		(-)
2/20	C	100 A	61.2	146.0	297.2	8.5	.435
		B	64.0	198.8	440.0	(16.40)	.567
		C	61.2	170.0	332.0		.511
	III	100 A	35.2	36.4	37.2	8.7	.0168
		B	34.8	36.0	32.0	(1.91)	.0170
		C	35.2	30.4	26.8		(-)
2/25	C	100 A	62.4	174.0	237.2	8.7	.513
		B	62.4	192.0	366.0	(18.70)	.562
		C	64.0	208.0	421.6		.589
	III	100 A	46.0	57.2	57.2	8.7	.109
		B	46.0	49.2	44.8	(2.49)	.0336
		C	46.8	52.8	46.0		.0603
3/4	C	100 A	65.2	214.8	389.2	8.7	.596
		B	64.0	198.8	372.0	(19.43)	.567
		C	64.8	209.2	372.8		.586
	III	100 A	35.6	32.8	39.2	8.7	.0891
		B	36.0	31.6	30.8	(1.73)	(-)
		C	36.0	37.6	29.6		.0217
3/11	C	100 A	60.0	121.2	180.4	8.7	.352
		B	61.2	151.6	216.4	(9.65)	.454
		C	60.0	121.6	180.4		.353
	III	100 A	37.6	32.4	32.8	8.7	.00614
		B	36.4	34.0	30.0	(3.43)	(-)
		C	37.2	34.4	27.6		(-)

APPENDIX 12. Continued

Date of Sample	Sample Type	Conc of Sample	Duration of Growth			Composite pH at (Suspended Solids)	$\hat{\mu}_b$ Days $^{-1}$
			1-Day Counts CELLS/mm^3	3-Day Counts CELLS/mm^3	5-Day Counts CELLS/mm^3		
3/18	C	100 A	84.0	323.2	585.0	8.7	.674
		B	87.6	438.4	831.0	(26.94)	.805
		C	84.0	405.6	773.0		.787
	III	100 A	51.2	52.0	36.4	8.7	.00775
		B	47.6	47.2	60.0	(3.43)	.120
		C	47.6	47.2	38.0		(-)
3/25	C	100 A	74.4	212.8	352.8	8.8	.525
		B	73.2	218.4	406.4	(15.90)	.547
		C	78.8	217.2	383.2		.507
	III	100 A	46.0	52.0	54.8	8.8	.0613
		B	46.0	52.0	56.8	(2.81)	.0613
		C	46.0	45.2	54.8		.0963
4/3	C	100 A	74.8	253.2	439.0	8.8	.610
		B	74.4	278.4	493.0	(21.78)	.660
		C	74.4	260.8	441.0		.627
	III	100 A	57.2	93.6	232.4	8.9	.455
		B	57.2	95.6	252.0	(8.78)	.485
		C	57.6	87.6	238.4		.501
4/8	C	100 A	77.6	255.2	440.0	8.8	.595
		B	78.4	256.8	416.0	(21.62)	.593
		C	76.4	269.6	510.0		.630
	III	100 A	50.0	59.2	114.0	8.8	.328
		B	50.8	60.0	132.4	(6.31)	.396
		C	52.0	74.8	155.2		.365
4/15	C	100 A	79.6	319.6	744.0	8.9	.695
		B	74.8	256.0	581.0	(24.44)	.615
		C	72.0	240.4	520.0		.603
	III	100 A	46.0	41.2	96.0	8.8	.423
		B	44.0	34.8	90.0	(2.69)	
		C	43.2	32.0	93.6		

APPENDIX 13

REPORT BY THOMAS WALSH (E Q A, INC.) TO LTAC ON UNDERWATER PHOTOGRAPHY

7/25/73
Photographs were taken at 900 ft and 1100 ft mark on T-1 transect. General observations of bottom conditions were made along the entire transect. There was heavy grass growth up to 150 ft offshore at a depth of approximately 25 ft. The bottom in the middle of the transect was made up of silt covered with a fine algal mat. The silt layer was from 2 to 6 inches deep.

7/26/73
Photographs were taken at 100 ft intervals from shore to 700 feet offshore along T-2 transect. Observations were made as to the general bottom conditions along the transect. There was heavy grass growth to a depth of 20 to 25 ft off both shores. From a depth of approximately 25 to 40 ft. The bottom consisted of silt with a fine algal mat. The silt layer was from 1/2 to 1 1/2 inches in depth. The bottom between a depth of 50 and 60 feet was made up of a silt layer 1 1/2 inches thick. There was no algal mat at this depth.

Photographs were taken at 3 different near shore shallow areas. There was one designated on the area map on pg. 1, 2, & 3.

7/27/73
Photographs were taken at 100 ft intervals from 700 feet offshore to the far shore along transect T-2. General bottom observations were the same as those made on transect T-2 on 7/26/73.

8/7/73
Photographs were taken along the main dam area. Interfaces were observed between silt, algae and grass. Growth of tall grass stopped at a depth of from 20-25 ft. Algal mat growth was observed to a depth of from 30 to 40 feet. From the 40 ft depth contain to a depth of 55 feet there was no algal growth.

Photographs and observations were made of the aeration tubes at a depth of 40 feet. The aeration tubes were free of silt and in good working condition.

8/2/73
Photographs were taken at station 3 at a depth of from 30 to 35 ft

Photographs were taken depicting the intervals between tall grass, algal mat, and silt. The interface between tall grass growth and algal mat-silt bottom was at a depth of between 20 and 25 feet. The interface between algal mat-silt bottom and silt bottom was at a depth of between 35 and 40 feet.

**ENVIRONMENTAL
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APPENDIX 14.

A DIVISION OF BROWN AND CALDWELL
SAN FRANCISCO ALHAMBRA

J. T. NORGAARD President
T. V. LUTGE Vice-President
M. L. WHITT Environmental Engineer
M. N. LIPSCHUETZ Laboratories
C. P. WALTON Ecologist
R. D. SMITH Oceanographer

L149A

April 27, 1973

Mr. P.H. McGauhey
Lake Tahoe Area Council
6819 Snowden Avenue
El Cerrito, California 94530

BENTHIC SURVEY -- INDIAN CREEK RESERVOIR

Dear Mr. McGauhey:

Enclosed are the results of the Indian Creek Reservoir benthos survey conducted on October 9, 1972. Nine stations were sampled, including eight stations in Indian Creek Reservoir and one station on Indian Creek as shown in Figure 1.

The methods used in this survey were essentially the same as in previous studies except that a Ponar dredge was used rather than an Ekman dredge. The Ponar dredge is a more efficient sampler even though a smaller area is sampled (five inches by six inches surface area versus six inches by six inches using the Ekman dredge).

Five samples were collected with each dredge from Station 1 for comparative purposes (Table 1). Although the mean number of organisms,expressed on a square foot basis, was more than twice as high when the Ponar dredge was used, it was not possible to calculate a conversion factor to equate the results of the present survey with the results of previous surveys. This was due to the high variation among replicate samples. We recommend the continued use of the Ponar dredge because of its increased efficiency, but suggest that comparisons between Ponar dredge sample data and Ekman dredge sample data be qualitative rather than quantitative.

The results of the survey (Table 2) showed that the predominant organisms were midge larva of the genera Procladius and Chironomus (Chironomus). At Station 1, located near the outfall, the diversity of species was lower than at stations located furthest from the outfall, such as Stations 5 and 6. Ephemeroptera, for example, were found at the latter stations, but not in the vicinity of the outfall. Although the diversity was lower, the density of organisms was greatest near the outfall, which is a biological indication of pollution.

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Table 3 shows the results of a sample collected by scrubbing rocks at Station 8. A relatively high population of leeches was found along with midge larvae, snails, and a few other organisms. This assemblage consists mostly of organisms which feed on the masses of decaying aquatic plants found in the area.

The sample from Station 9 on Indian Creek consisted primarily of tubificid worms (Table 4). This is indicative of organic pollution.

To summarize, the results of this survey showed that the benthos of Indian Creek Reservoir was predominately midge larvae. The highest density and lowest diversity of organisms was found nearest the outfall. The shoreline and Indian Creek samples both contained organisms characteristic of waters with decaying organic material. A comparison of samples collected by a Ponar dredge and a Ekman dredge showed that it was not feasible to compare the results on a quantitative basis.

We appreciate this opportunity to provide services in the water quality field. If any questions arise regarding this survey, please do not hesitate to contact us.

Very truly yours,

ENVIRONMENTAL QUALITY ANALYSTS, INC.

CPWalton

C.P. Walton, Ph.D.

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APPENDIX 14 (continued).

Table 4. Sample from Indian Creek

Station 9

Organism	Number Per 0.5% Aliquot	Organisms Identified Number Per 5.0% Aliquot	Organisms Identified Number Per Entire Sample	Computed Number Per Entire Sample
Oligochaeta				
Tubificidae	437	--	--	87400
Hirudinea				
Glossiphoniidae				
Helobdella ?	--	--	1	1
Hirudidae	--	--	2	2
Amphipoda				
Hyalellidae				
Hyalella azteca	--	--	46	46
Hydracarina	--	--	2	2
Ephemeroptera				
Baetidae				
Baetis sp.	--	6	--	120
Zygoptera				
Coenagrionidae				
Amphiagrion sp.	--	--	2	2
Argia sp.	--	--	20	20
Hemiptera				
Gerridae				
Gerris sp.	--	--	3	3
Trichoptera				
Hydropsychidae				
Hydropsyche sp.	--	155	--	3100
Coleoptera				
Dytiscidae				
Agabus sp.	--	--	5	5
Coptotomus sp.	--	--	30	30
Laccodytes sp.	--	--	23	23
Diptera				
Simuliidae	--	14	--	280
Chironomidae				
Tanypodinae				
Procladius sp.	--	1	--	20
Orthocladiinae				
Cardiocladius sp.	--	4	--	80
Corynoneura sp.	--	10	--	200
Cricotopus sp.	--	137	--	2740
Nanocladius sp.	--	16	--	320
Trichocladius sp.	--	1	--	20
Chironominae				
Micropsectra sp.	--	18	--	360
Unidentified pupae	--	12	--	240
Tabanidae				
Tabanus sp.	--	--	1	1
Muscidae				
Limnophora sp.	--	--	3	3
Unidentified pupae	--	--	1	1
Gastropoda				
Physidae				
Physa sp.	--	--	5	5
Planorbiidae				
Gyraulus parvus	--	--	1	1
Planorbella subcrenatum	--	--	2	2
Total Organisms	437	374	147	95027

APPENDIX 14 (continued).

Table 2. Samples Collected by Ponar Dredge (Continued)

Station 7

Organism	Sample a
Cladocera	
Ephippia*	1000
Hirudinea	
Glossiphoniidae	
Helobdella ?	4
Hydracarina	2
Zygoptera	
Coenagrionidae	
Ischnura sp.	6
Diptera	
Chironomidae	
Tanypodinae	
Procladius sp.	5
Orthocladiinae	
Metriocnemus sp.	5
Chironominae	
Paralauterborniella sp.	1
Tanytarsus sp.	1
Gastropoda	
Planorbidae	
Gyraulus parvus	8
Total Organisms	32
Volume (liters)	0.6
Organisms Per Square Foot	150

Table 3. Sample Collected from Rocks

Station 8

Organism	Sample a
Hirudinea	
Glossiphoniidae	
Helobdella ?	229
Amphipoda	
Hyalellidae	
Hyalella azteca	56
Zygoptera	
Coenagrionidae	
Ischnura sp.	1
Coleoptera	
Elmidae	
Optioservus sp.	1
Diptera	
Chironomidae	
Orthocladiinae	
Corynoneura sp.	2
Cricotopus sp.	202
Metriocnemus sp.	2
Chironominae	
Paralauterborniella sp.	40
Gastropoda	
Physidae	
Physa sp.	3
Lymnaeidae	
Radix auricularia	11
Planorbidae	
Gyraulus parvus	63
Planorbella succrenatum	1
Total Organisms	611

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*Estimated number, not included in sample totals.

APPENDIX 14 (continued).

Table 2. Samples Collected by Ponar Dredge (Continued)

Station 6

Organism	Sample a
Cladocera	
Ephippia*	2000
Coelenterata	
Hydrozoa	
Hydra sp.	4
Oligochaeta	
Tubificidae	1
Hirudinea	
Glossiphoniidae	
Helobdella ?	1
Ephemeroptera	
Baetidae	
Callibaetis sp.	4
Zygoptera	
Coenagrionidae	
Ischnura sp.	1
Diptera	
Chironomida	
Tanypodinae	
Procladius sp.	18
Orthocladiinae	
Corynoneura sp.	5
Cricotopus sp.	1
Metriocnemus sp.	17
Chironominae	
Paralauterborniella sp.	3
Unidentified pupae	3
Gastropoda	
Physidae	
Physa sp.	1
Lymnaeidae	
Radix auricularia	4
Planorbidae	
Gyraulus parvus	232
Total Organisms	295
Volume (liters)	0.5
Organisms Per Square Foot	1400

*Estimated number, not included in sample totals.

APPENDIX 14 (continued).

Table 2. Samples Collected by Ponar Dredge (Continued)

Station 5

Organism	Sample a	b	c	Total	Mean
Cladocera					
Ephippia*	3000	3000	2000	8000	2700
Hirudinea					
Glossiphoniidae					
Helobdella ?	--	1	--	1	0.3
Amphipoda					
Hyalellidae					
Hyalella azteca	6	8	1	15	5.0
Hydracarina	2	1	1	4	1.3
Ephemeroptera					
Baetidae					
Callibaetis sp.	2	5	15	22	7.3
Diptera					
Chironomidae					
Tanypodinae					
Pentaneurini	--	1	4	5	1.7
Procladius sp.	23	10	137	170	56.7
Chironominae					
Chironomus (*Chironomus*) sp.	1	27	8	36	12.0
Tanytarsus sp.	15	2	31	48	16.0
Unidentified pupae	--	--	1	1	0.3
Gastropoda					
Planorbidae					
Gyraulus parvus	1	--	1	2	0.7
Total Organisms	50	55	199	304	101.3
Volume (liters)	0.7	0.5	0.9	2.1	0.7
Organisms Per Square Foot	240	260	960	1460	490

*Estimated number, not included in sample totals.

APPENDIX 14 (continued).

Table 2. Samples Collected by Ponar Dredge (Continued)

Station 3

Organism	Sample a	b	c	Total	Mean
Cladocera					
Ephippia*	5000	3000	4000	12000	4000
Coelenterata					
Hydrozoa					
Hydra sp.	8	52	37	97	32.2
Hirudinea					
Glossiphoniidae					
Helobdella ?	--	--	2	2	0.7
Amphipoda					
Hyalellidae					
Hyalella azteca	--	2	2	4	1.3
Hydracarina	103	35	121	259	86.3
Diptera					
Chironomidae					
Tanypodinae					
Procladius sp.	69	50	53	172	57.3
Chironominae					
Chironomus (*Chironomus*) sp.	--	9	2	11	3.6
Tanytarsus sp.	5	9	1	15	5.0
Unidentified pupae	1	--	--	1	0.3
Gastropoda					
Planorbidae					
Gyraulus parvus	1	--	--	1	0.3
Planorbella subcrenatum	--	1	--	1	0.3
Total Organisms	187	158	219	564	188.0
Volume (liters)	0.9	0.5	0.5	1.9	0.6
Organisms Per Square Foot	900	760	1100	2760	920

Station 4

Organism	Sample a	b	c	Total	Mean
Cladocera					
Ephippia*	2000	4000	2000	8000	2700
Coelenterata					
Hydrozoa					
Hydra sp.	15	23	--	38	12.7
Hydracarina	40	5	20	65	21.7
Diptera					
Chironomidae					
Tanypodinae					
Procladius sp.	97	105	74	276	92.0
Chironominae					
Chironomus (*Chironomus*) sp.	14	41	121	176	58.7
Tanytarsus sp.	17	7	1	25	8.3
Unidentified pupae	3	--	--	3	1.0
Gastropoda					
Planorbidae					
Gyraulus parvus	1	--	2	3	1.0
Total Organisms	187	181	218	586	195.3
Volume (liters)	0.7	0.9	0.9	2.5	0.8
Organisms Per Square Foot	900	870	1000	2770	920

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*Estimated number, not included in sample totals.

APPENDIX 14 (continued).

Table 2. Samples Collected by Ponar Dredge

Station 1

Organism	Sample						
	a	b	c	d	e	Total	Mean
Cladocera							
Ephippia*	5000	20000	5000	8000	5000	43000	8600
Hydracarina	43	80	6	6	8	143	28.6
Diptera							
Chironomidae							
Tanypodinae							
Procladius sp.	26	19	20	14	12	91	18.2
Chironominae							
Chironomus (Chironomus) sp.	91	80	49	92	93	405	81.0
Polypedilum sp.	--	--	--	1	--	1	0.2
Gastropoda							
Planorbidae							
Gyraulus parvus	1	1	2	1	--	5	1.0
Total Organisms	161	180	77	114	113	645	129.0
Volume (liters)	1.6	1.6	0.5	0.7	0.7	5.1	1.0
Organisms Per Square Foot	770	860	370	550	540	3090	620

Station 2

Organism	Sample				
	a	b	c	Total	Mean
Cladocera					
Ephippia*	2000	2000	2000	6000	2000
Coelenterata					
Hydrozoa					
Hydra sp.	10	32	5	47	15.7
Hirudinea					
Glossiphoniidae					
Helobdella ?	--	2	1	3	1.0
Amphipoda					
Hyalellidae					
Hyalella azteca	6	3	2	11	3.6
Hydracarina	--	97	48	145	48.3
Diptera					
Chironomidae					
Tanypodinae					
Procladius sp.	12	33	26	71	23.7
Chironominae					
Chironomus (Chironomus) sp.	1	--	1	2	0.7
Chironomus (Cryptochironomus) sp.	1	--	--	1	0.3
Tanytarsus sp.	11	8	9	28	9.3
Total Organisms	41	175	92	308	102.7
Volume (liters)	0.7	0.7	0.7	2.1	0.7
Organisms Per Square Foot	200	840	440	1480	490

*Estimated number, not included in sample totals.

APPENDIX 14 (continued).

BENTHIC ORGANISM SURVEY, INDIAN CREEK RESERVOIR,

October 9, 1972

Table 1. Comparison of Samples Collected by Ponar and Ekman Dredge

Samples Collected by the Ponar Dredge

	Sample							
Organism	a	b	c	d	e	Total	Mean	Percent
Cladocera								
Ephippia*	5000	20000	5000	8000	5000	43000	8600	--
Hydracarina	43	80	6	6	8	143	29.6	22.9
Diptera								
Chironomidae								
Tanypodinae								
Procladius sp.	26	19	20	14	12	91	18.2	14.1
Chironominae								
Chironomus (Chironomus) sp.	91	80	49	92	93	405	81.0	62.8
Polypedilum sp.	--	--	--	1	--	1	0.2	0.2
Gastropoda								
Planorbidae								
Gyraulus parvus	1	1	2	1	--	5	1.0	0.8
Total Organisms	161	180	77	114	113	645	129.0	100.8
Volume (liters)	1.6	1.6	0.5	0.7	0.7	5.1	1.0	--
Organisms Per Square Foot	770	860	370	550	540	3090	620	--

Samples Collected by the Ekman Dredge

	Sample							
Organism	a	b	c	d	e	Total	Mean	Percent
Cladocera								
Ephippia*	2000	5000	2000	4000	2000	15000	3000	--
Coelenterata								
Hydrozoa								
Hydra sp.	--	6	7	4	4	21	4.2	5.8
Hirudinea								
Glossiphoniidae								
Helobdella ?	1	--	--	--	--	1	0.2	0.3
Hydracarina	--	12	2	3	--	17	3.4	4.7
Diptera								
Chironomidae								
Tanypodinae								
Procladius sp.	4	17	17	26	14	78	15.6	21.7
Chironominae								
Chironomus (Chironomus) sp.	31	76	29	78	26	240	48.0	66.9
Polypedilum sp.	--	--	--	1	1	2	0.4	0.6
Total Organisms	36	111	55	112	45	359	71.8	100.0
Volume (liters)	0.5	0.5	0.5	0.7	0.7	2.9	0.6	--
Organisms Per Square Foot	140	440	220	450	180	1430	290	--

*Estimated number, not included in sample totals.

APPENDIX 14 (continued).

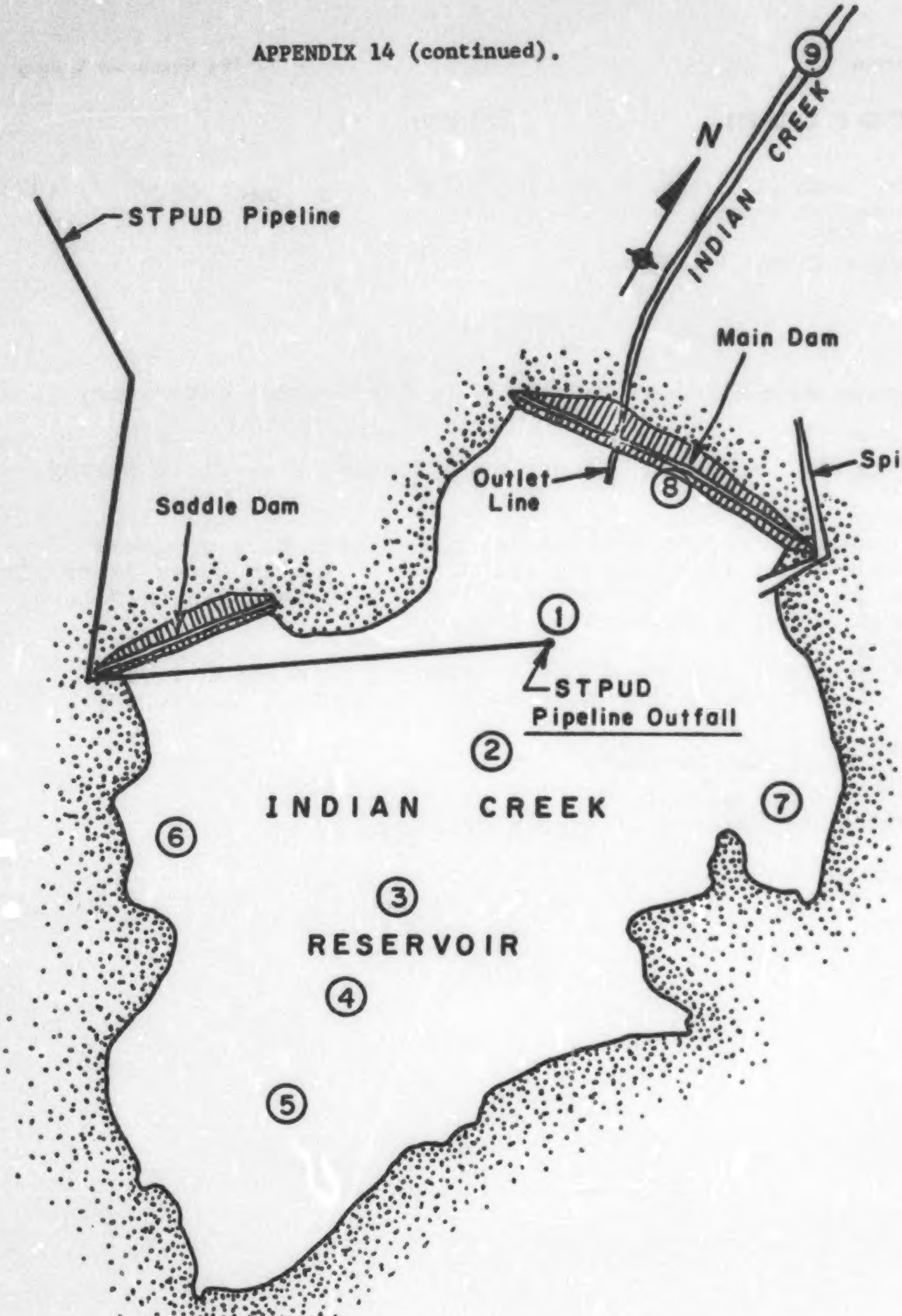
9
N
INDIAN CREEK
STPUD Pipeline
Main Dam
Spillway
Outlet Line
8
Saddle Dam
1
STPUD Pipeline Outfall
2
INDIAN CREEK
7
6
3
RESERVOIR
4
5

Fig. 1. Location of Sampling Stations at Indian Creek Reservoir

State of California **The Resources Agency**

Memorandum

APPENDIX 15

To : Mr. John D. Archambault
Lake Tahoe Area Council
Box 575
Tahoe City, Calif.

Date: March 7, 1973

From : Department of Fish and Game Water Pollution Control Laboratory

Subject: Progress Report on Indian Creek Reservoir -- Field Survey

Attached for your information is a laboratory progress report on a field survey conducted at Indian Creek Reservoir in March 1972. Further work is planned in the near future, followed by a more detailed report.

If you have any questions concerning this report, feel free to contact the Water Pollution Control Laboratory.

Fredric Kopperdahl

Fredric Kopperdahl
Associate Water Quality Biologist

Attachment

INDIAN CREEK RESERVOIR -- FIELD SURVEY

During March, 1972, a large dieoff of rainbow trout occurred in Indian Creek Reservoir, Alpine County. This loss was discovered and monitored closely by the Department of Fish and Games' regional biologist and personnel from the Nimbus Water Pollution Control Laboratory (WPCL). Physical and chemical data of the lake water collected during the dieoff period indicated that high ammonia levels coupled with high pH was the probable cause of the fish mortalities. In conjunction with water chemistry studies, live car and laboratory tests were conducted.

Physical and Chemical Evaluations - Vertical profiles of hydrogen ion concentration (pH), dissolved oxygen (D.O.) and temperature were recorded from five stations covering the period from 0645 in the morning until 1800 hours in the evening (Table 1, Figure 1). Ammonia samples were taken on the surface at station 1 and preserved with sulfuric acid for later analyses at the laboratory.

Live Car Studies - Live cars, containing five rainbow trout each, were placed in the Reservoir at stations 1 & 2. Fish were held at mid-depth, three feet from the bottom and three feet from the surface. Eighty percent mortality occurred after two days of exposure at all three depths with 100% mortality occurring within three days.

Laboratory Tests

Ten gallons of lake water was collected from the surface at station 1 and packed in ice for transport to the laboratory. Bioassays, using rainbow trout, at varying dilutions of lake water and adjusted pH levels were conducted at the laboratory at temperatures of 15 and 18° centigrade (°C).

TABLE 1

Physical-Chemical Data, Indian Creek Reservoir
(0645-1800 March 16, 1972)

Time 06:45 Sunrise 0600
Air Temp. 6°C Clear-Strong Breeze

Station	Time	Depth (ft)	pH	D.O. (mg/l)	Temp. °C	NH_4 (mg/l)
1	0648	Surface	8.7	>15	9.5	7.1
	0645	40	8.6	>15	8.0	
2	0713	Surface	8.7	>15	8.5	
	0710	16	8.7	>15	8.5	
3	0730	Surface	8.6	>15	8.0	
	0725	8	8.6	14.9	8.5	
Time 13:00 Air Temp. 16°C		Clear and Calm				
1	1303	Surface	9.0	>15	11.0	7.3
	1300	40	8.9	>15	10.0	
3	1315	Surface	9.0	>15	12.0	
	1310	8	9.1	>15	11.0	
5	1345	Surface	9.2	>15	12.0	
	1340	22	9.0	>15	11.0	
2	1430	Surface	9.2	>15	11.0	
Time 17:15 Air Temp. 11.5°C		Sunset 1720 Clear-Slight Breeze				
2	1720	Surface	9.4	>15	11.0	
	1715	16	9.3	>15	9.5	
5	1725	Surface	9.4	>15	11.5	
3	1738	Surface	9.4	>15	14.0	
	1735	10	9.3	>15	12.0	
4	1745	Surface	9.2	>15	10.5	
1	1800	Surface	9.2	>15	9.0	7.3
	1755	40	9.1	>15	9.0	

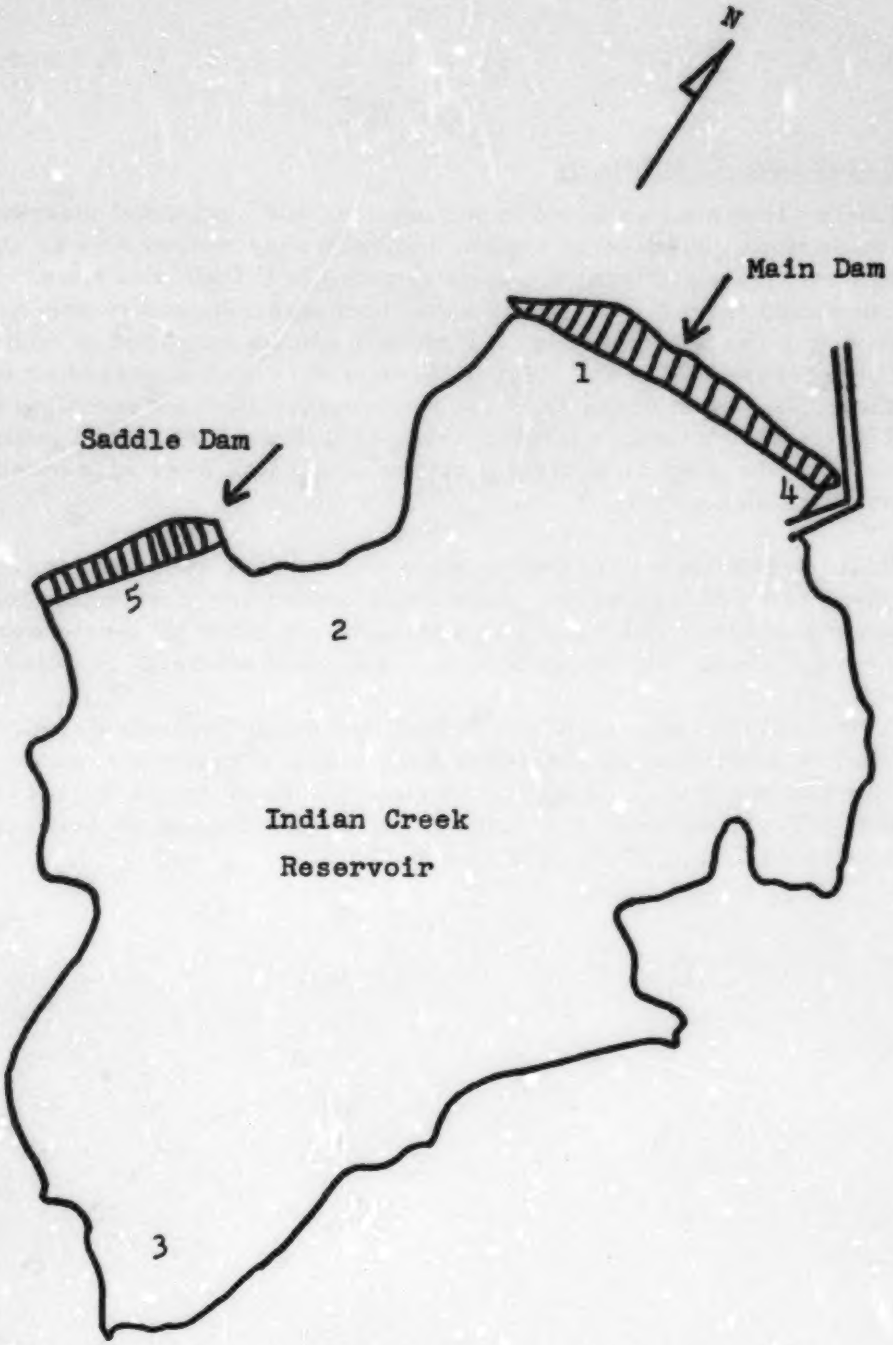
N
Main Dam
1
Saddle Dam
4
5
2
Indian Creek
Reservoir
3

Figure 1. Location of Sampling Stations at Indian Creek Reservoir

Results and Conclusions

Little variation was noted in the vertical and horizontal distribution of the various constituents tested, indicating the reservoir was well mixed. However, a significant change was noted in the pH with time. The pH increased from a low of 8.6 in the morning to approximately 9.0 at noon to 9.4 in the late afternoon. Fish mortalities appeared to coincide with the increased pH level. Few fish were observed in stress or dead throughout most of the day; however, during the last sampling period, 1700 to 1800 hours, a large number of fish were observed swimming close to the surface in tight circles. Dead fish were also noted floating near the shore line.

This phenomenom was duplicated under laboratory conditions. In bioassay tests of lake water, no mortalities occurred when ammonia levels were between 7 and 8 mg/l at a pH of 8.6. When pH levels were increased above 9.0, signs of stress and eventual death resulted.

Temperatures may also be a factor that should be considered. In studies conducted at the laboratory using a reservoir water at 15°C and 6-8 mg/l ammonia, the critical pH level would be between 9.0 and 9.1. However, the critical pH level dropped to between 8.6 and 8.8 at 18°C and 3-5 mg/l ammonia.